Develop, Discuss, and Decide:
How New Science Teachers Use
Technologies to Advance Their Practice

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Joshua Alexander Ellis

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Dedication

Do not confine your children to your own learning, for they were born in another time.

- Chinese proverb

This dissertation is dedicated to all of the educators who refuse to teach as they have been taught and embrace the promise of tomorrow. This work is inspired by those teachers among us who are brave enough to think beyond their own experiences, humble enough to put their learners first, and wise enough to strive for where the two meet.

Abstract

For decades, there has been a nationwide demand to increase the number of science teachers in K-12 education (National Commission on Excellence in Education, 1983; National Research Council [NRC], 2007). This demand is in large part due to increases in state science graduation requirements. Teacher preparation programs have been preparing new science teachers on pace with the resulting increase in demand (Ingersoll & Merrill, 2010), however, shortages have continued as up to 50% of these new teachers leave the profession within their first five years of teaching (Smith & Ingersoll, 2004), creating a "revolving door" phenomenon as districts scramble to address this early attrition with yet more beginning teachers. We need to address what Ingersoll (2012) describes as the "greening" of the teaching force: the fact that an increasingly large segment of the teaching force is comprised of beginning teachers who are at a high risk of leaving the profession.

The three related studies that comprise this dissertation focus on the role of technological interventions for in-service and pre-service science teachers. The context for the first two studies is TIN, an online induction program for beginning secondary science teachers. These two studies consider the impact of technological supports on the reflective practice of participating teachers. The design interventions included VideoANT (an online video annotation tool) and Teachers as Leaders roles (a structured response protocol) for the Venture/Vexation online forum activity. The context for the third study is T^3-S, a university licensure course for pre-service science teachers designed to explore technology integration in secondary science classrooms. This study investigated the impact of pre-service teacher participation in the creation of an Adventure Learning (AL) environment (Doering, 2006) on their understanding of technological, pedagogical, and content knowledge (TPACK) and its role in their future science instruction. The supporting interventions took the form of three separate groups of pre-service teachers, each tasked with a specific role in the creation of the AL environment.

Findings from the first two studies indicate that specific, explicit supports for teacher discourse in TIN activities is needed in order to foster the reflective practice that course designers and instructor-facilitators desire. The third study reveals that pre-service teacher participation in the creation of an AL environment supported their understanding of the nature of TPACK and allowed them to define their content-based technology pedagogy for future science instruction.

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CHAPTER 1

Introduction: Studies 1 and 2

For decades, there has been a nationwide demand to increase the number of science teachers in K-12 education (National Commission on Excellence in Education, 1983; National Research Council [NRC], 2007). Teacher preparation programs have been preparing new science teachers on pace with the resulting increase in demand (Ingersoll & Merrill, 2010), however, shortages have continued as up to 50% of these new teachers leave the profession within their first five years of teaching (Smith & Ingersoll, 2004), creating a "revolving door" phenomenon as districts scramble to address this early attrition with yet more beginning teachers. The education field needs to address what Ingersoll describes as the "greening" of the teaching force: the fact that an increasingly large segment of the teaching force is comprised of beginning teachers who are at a high risk of leaving the profession (Ingersoll, 2012).

An accepted approach to ameliorating this problem is the implementation of induction programs, which serve beginning teachers through support, guidance, and orientation (Smith & Ingersoll, 2004). Unlike other professions, the teaching occupation does not boast an established, structured process of initiation into the profession. Opportunities for teachers to participate in in-service training, such as professional development and workshops, do exist. However, induction programs provide coherent, targeted support for beginning teachers who are most at risk for leaving the school or the profession. Smith and Ingersoll (2004) demonstrate that quality induction programs (i.e.., those that go beyond the simple provision of a mentor) do indeed improve teacher retention.

Smith and Ingersoll (2004) identify mentoring as a hallmark of induction programs, where personal guidance is provided to beginning teachers. Mentoring is an intrinsically valuable practice for the development of beginning teachers. Smith and Ingersoll (2004) note that, in addition to improving teacher retention, mentoring also has the potential to improve the job satisfaction and efficacy of teachers. However, mentoring in other professions is often directed towards developing the practice of novices. One approach toward building novice knowledge and expertise through collaboration with more experienced professionals is the creation of a community of practice. Zeichner and Liston (1987) and Wenger (1998) describe communities of practice as groups of people who improve their practice through mentoring and collaboration with one another, sharing knowledge for the purpose of increasing the skills of novices in the community. The professional growth of beginning teachers is an outcome of induction programs that has not been explored to the extent that outcomes for retention have been studied. To focus solely on retention is to miss an opportunity for induction to promote the instructional practices of beginning teachers (Roehrig, Donna, Billington, & Hoelscher, in press). In short, it is time to consider how induction can improve the practice and growth of beginning teachers in addition to its effect on teacher retention.

National guidelines for teacher preparation and induction advocate the development of teachers as reflective practitioners (Council for the Accreditation of Educator Preparation, [CAEP], 2013). Dewey (1933) and Rodgers (2002) state that the primary objective of reflection-on-action is to promote the more difficult reflection-in-action. Reflection-in-action refers to the instantaneous response or action given in a situation as it unfolds in real-time (Schön, 1984). Reflection-on-action occurs after an event via a conscious and disciplined process ending with analysis of the experience and experimentation with possible methods of action (Zeichner & Liston, 1996; Rodgers, 2002). By guiding beginning teachers in reflection within the context of an induction program, we can help them develop their capacity to reflect on past, present, and future teaching practice (Killion & Todnem, 1991).

The first two papers of this dissertation consider the development of reflective practice of beginning secondary science teachers in an online induction program called the Teacher Induction Network, or TIN (Roehrig, Donna, Billington, & Hoelscher, in press). These studies explore the unique affordances for reflective practice that occur in an online community of practice, where physical proximity is no longer a barrier to community. TIN is currently entering its ninth year of operation and has served over 180 teachers during its existence. Roehrig et al. (in press) identified the need for a systematic examination of the interactions of beginning teachers in TIN. This assessment is critical to understanding how TIN affords opportunities for individual learning needs, interaction and collaboration, and mediation of learning online. Therefore, TIN has been continually developed through design-based research strategies (Design-Based Research Collective, 2003), which primarily focus on the interactions between the teacher-participants and the educational, social, and technological affordances of the online learning environment (Kirschner, Strijbos, Kreijns, & Beers, 2004). Roehrig et al. (in press) describe the unique tools and strategies they employed for the purpose of developing the instructional practices of beginning teachers. One strategy is the use of a video annotation tool for teachers to reflect on their own teaching and provide evidence of their professional growth. This video annotation activity was explored by McFadden, Ellis, Anwar, and Roehrig (2014). They revealed that teachers focused on themselves when commenting on video of their own teaching practice, and they rarely used this tool to evaluate or interpret the teaching events in the video. The first two papers seek to extend this line of inquiry into the effect of online tools in TIN on the reflective practice of beginning teacher participants. The following section will more thoroughly describe the importance of reflective practice and communities of practice.

Theoretical Framework: Studies 1 and 2

Reflective Practice

National guidelines for teacher preparation and induction advocate the development of reflective practitioners (National Council for Accreditation of Teacher Education [NCATE], 2008; Teacher Education Accreditation Council [TEAC], 2008). Reflective practice is well established as central to the teaching and learning process of student teachers (Zeichner & Liston, 1987; Harford & MacRuairc, 2008), bridging the gap between theory and practice through an integration of experience and reflection. Both Dewey (1933) and Tickle (2000) note the importance of active engagement with problematic situations, a practice that continues to be useful as teachers enter the profession. Dewey (1933) identifies two ways that reflective practitioners can participate in this engagement: reflection-on-action and reflection-in-action. He states that the primary objective of reflection-on-action is to promote the more difficult reflection-in-action, which refers to the instantaneous response or action given in a situation as it unfolds in real-time (Schön, 1984). Rodgers (2002) further defined reflection-on-action as a conscious and disciplined process that occurs after an experience and ends with analysis of that experience and experimentation with possible courses of action. This view is rooted in Dewey's (1933) three stages of reflection-on-action: *description, analysis,* and *action*. Within the context of classroom instruction, a teacher can engage in *description* and *analysis* of his or her teaching practice after the fact. The following *action* occurs when the teacher returns to the classroom and implements the new or modified teaching practice that will then be reflected on moving forward. This form of reflective practice is the hallmark of a master teacher, and takes many years to develop.

In addition to reflection-on-action and reflection-in-action, Killion and Todnem (1991) include a third type of reflection called reflection-for-action, which adds reflection for future action in addition to reflection on past and present action. Reflection-for-action is the ultimate goal of reflection-on-action and reflection-in-action, as it goes beyond visiting past practice or growing in-the-moment awareness in order to guide future action (Killion & Todnem, 1991). This knowledge-generation for future actions is not only practical but necessary for beginning teachers who strive to improve their future instruction. Taken together, all three forms of reflection provide the beginning teacher with a framework for making sense of their teaching practice and framing discussions for their continued professional development.

As Kirschner, Strijbos, Kreijns, and Beers (2004) describe, technologies can provide unique affordances for reflection and learning. An example of such a technological affordance is the use of video of past instruction to guide reflective practice. Through reflection on video, teachers can explore their successes and struggles, identify elements of their teaching that contribute to those successes and struggles, and elicit feedback from peers that may guide the teacher towards improving their practice (Le Fevre, 2004). Other technological affordances in TIN include synchronous and asynchronous discussions, small online learning communities, and blogging as described by Roehrig, et al. (in press). This emphasis on promoting discourse and creating communities is an important first step when crafting an environment that promotes reflective practice, and the designers of TIN select technologies and strategies that help to build this kind of community within an online environment.

Communities of Practice

In order for teachers to develop their practice in meaningful ways, they must situate themselves within a community of practice (Zeichner & Liston, 1987) where they can bolster their growing teaching knowledge and experience in conjunction with their peers. Staver (1998) notes that when knowledge is built in conjunction with one's peers, it is deemed useful by those involved. This pragmatic view on socially constructed knowledge is well-suited for proponents of reflective practice.

Communities of practice are composed of people who engage in collective learning in a shared domain of interest (Wenger, 1998), such as teachers in an induction program. Members of such communities improve their practice in this domain as they interact with one another on a regular basis. The activities of communities of practice can vary widely; problem solving, seeking information or experience, and discussing new developments are all examples of activities that members of a community of practice can engage in to advance their practice. A community of practice for beginning teachers, for example, would be centered on learning in the shared domain of K-12 teaching. This community would allow beginning teachers to engage in problem solving, discussion, and support of one another as they navigate their first years of teaching in K-12.

Introduction: Study 3

Researchers have begun to craft specific recommendations for the integration of technology within science education. Flick and Bell (2000) suggest that science educators must take advantage of the unique features of technology, use technology to make scientific views more accessible, and develop an understanding of the relationship between science and technology. Hughes (2005) claims that teachers must have a technology-supported pedagogy and skills base in order to effectively integrate technology into their instruction. An accepted framework for defining the role of technology in education is the Technological Pedagogical Content Knowledge Framework, or TPACK (Mishra & Koehler, 2006; Koehler, Mishra, Akcaoglu, & Rosenberg, 2013). This framework has been used to assess the capacity for pre-service teachers to effectively integrate technology (Schmidt et al., 2009; Hechter, Phyfe, & Vermette, 2012) and to better understand pre-service teachers' perceptions and awareness of TPACK (Hechter & Phyfe, 2010; Hechter, 2012). However, there is little literature that explores the effect of targeted interventions on improving pre-service teacher understanding of TPACK. As in TIN, instructors in the teacher education program described here wish to determine which educational, social, and technological affordances (Kirschner et al., 2004) contribute most positively to promoting pre-service teacher understanding of technology integration for K-12 instruction.

Technology Tools for Teachers (T^3) is a course offered at the University of Minnesota to pre-service teachers in all content areas. The section for science educators, T^3-S, is designed to guide future science teachers to use technologies applicably in science classroom settings (Hughes, 2005), develop a personal understanding of technological affordances and limitations based on research and experience, and create a vision for teaching and learning science with technological support (Hechter & Vermette, 2012). This study explores the impact of targeted instructional interventions within T^3-S on increasing pre-service teacher understanding of the role of technological interventions in classroom learning environments.

Theoretical Framework: Study 3

Technology Integration

In the context of STEM integration, significant focus has been given to engineering integration in recent years (NRC, 2013; Moore et al., 2014). By comparison, technology is the STEM discipline with the least formalization and operationalization of knowledge within the context of K-12 education. Calls to address this gap have been made for over 25 years, starting most prominently with the Project 2061 Technology

Panel (Johnson, 1989). Thornburg (1999) identified four pillars for a national plan regarding technology in education: 1) modern learning devices will be accessible to all students, 2) classrooms will be connected to other classrooms around the world, 3) educational software will be an integral curriculum component, and 4) teachers will be prepared to teach with technology. Sadly, few of these goals have been realized in part, if at all; in a review of the literature, Hew and Brush (2007) note that there still exist significant barriers to technology integration, especially with regard to the availability of digital resources and the knowledge and skills of teachers using this technology.

Hughes (2004) calls for teacher education programs that create *technology integrationists* - teachers who possess “the unique ability to understand, consider, and choose to use technologies *only* when they uniquely enhance the curriculum, instruction, and students’ learning (p. 346)”. In order to make these explicit connections between technology integration and student learning, groups of individuals from the same subject area often gather to share their strategies for technology integration, either formally (as part of a professional learning community or professional development activity) or informally (through conversations with colleagues, both in-person and online). Hughes (2005) finds that these subject-specific technology inquiry groups promote content-based technology pedagogy, while instruction that focuses solely on the technology results in technology pedagogy that fails to make connections to content. Therefore, in order to create a community that promotes technology-integrated instruction that serves both content and pedagogy, we must draw upon a framework that explicitly relates content, pedagogy, and technology for instruction.

Research Design: Studies 1, 2, and 3

Design-based Research (DBR)

The ongoing development of both TIN and T^3-S is framed through design-based research strategies (Design-Based Research Collective, 2003; Barab & Squire, 2004) that examine the interactions between participants and the educational, social, and technical affordances of the online environment. Design-based research (DBR) is not a single approach but rather a series of approaches intended to advance design, research, and practice concurrently (Barab & Squire, 2004; Wang & Hannafin, 2005). DBR contains pragmatist philosophical underpinnings, which hold that the value of a theory lies in its ability to produce change (e.g., Dewey 1993). Therefore, a primary goal of DBR implementation is to produce demonstrable changes at the local level that have broader significance (Barab & Squire, 2004). DBR is a particularly effective approach in what Wang and Hannafin (2005) identify as a technologically enhanced learning environment (TELE), such as T^3-S or TIN. This is due to the fact that, unlike a purely face-to-face classroom, the TELE designer is responsible for every aspect of the environment that the students participate in online. This places a great emphasis on the design, redesign, and improvement of TELEs when considering factors that affect student interactions in an online environment. Although TELE designers do not exercise complete control over the learning environment, everything from the selection of the content management system to the online activities that teachers participate in provides an opportunity for the designer/instructor to make purposeful decisions regarding the nature and impact of their technologically afforded instruction. In T^3-S and TIN, we use DBR as a paradigm from which we consider the impact of our technologically afforded activities.

More specifically, DBR has driven the three related studies that comprise this dissertation. McKenney and Reeves (2013) state that "[t]he goal is to unearth the most powerful overlap between researcher expertise/interests and practitioner needs/interests" (p. 89), and the pursuit of this goal has led to the research questions that comprise each of these studies. The conclusions of each study impact both researcher expertise and practitioner needs by answering questions and posing new ones, shifting the landscape of interests and areas of overlap. Therefore, each following study aims to address the new areas of overlap in light of the study that preceded it. This paradigmatic approach to DBR differs from other approaches that seek to iterate and generalize specific interventions or strategies; rather, DBR in TIN and T^3-S serves to refine researcher expertise in the area of technology-assisted reflective practice and improve educational, social, and technological affordances for beginning practitioners. Further, this iterative and analytic process serves an equally important goal of helping beginning science teachers to transition from consumers of educational technologies to creators of meaningful technology-integrated science instruction.

Research Arc

The two guiding research questions that set the stage for the studies that followed are:

1. How do beginning STEM teachers reflect on science teaching practices?
2. How do they utilize technologies to support their colleagues and themselves?

The pursuit of these questions led to three studies that address the following areas:

1. How technology helps teachers reflect on video of past teaching practice
2. How technology helps teachers solve problems in their classrooms
3. How technology helps teachers plan for integrated instruction

This research arc is the product of an evolving research subject with respect to the original guiding research questions. All three studies are situated in the context of reflective practice, and one of the goals that we identify for our beginning teachers is to move from reflecting on past action towards reflecting in the moment and reflecting for future instruction (see Table 1.1). As researchers, we have followed a parallel process in the ways in which we seek to address our guiding research questions. DBR has facilitated our progression from research reflecting *on* action (in the form of past teaching) to reflecting *in* action (in current teaching) and finally to reflecting *for* action (in planning for future instruction).

Table 1.1. Outline of the three studies.

	Study 1	**Study 2**	**Study 3**
Title	Investigating the Social Interactions of New Science Teachers Using a Video Annotation Tool	Teachers as Leaders: Exploring the Venture Vexation Activity in an Online Induction Program	Using an Adventure Learning Environment to Develop Science Teachers' TPACK
Research Question	How do beginning teachers respond to a peer's initial annotations on their own teaching using a video annotation tool?	What is the impact of Teachers as Leaders roles on group cohesion and depth of reflection in the Venture Vexation activity?	How do pre-service science teachers' understanding of TPACK change after participating in the creation of an adventure learning environment?
Research Subject	Reflection-on-action	Reflection-in-action	Reflection-for-action

CHAPTER 2

STUDY 1

Introduction

For decades, there has been a nationwide demand to increase the number of science and mathematics teachers in K-12 education (National Research Council [NRC], 2007). Recently, teacher preparation programs have been successful in graduating enough teacher candidates to keep pace with the increased demand for secondary science and mathematics teachers (Ingersoll & Merrill, 2011); however, up to 50% of these new teachers leave the profession within their first five years of teaching (Smith & Ingersoll, 2004). This poor retention of beginning teachers creates continued teacher shortages and a "revolving door" phenomenon as districts scramble to address this early attrition with the hiring of more beginning teachers. It is critical that the education community address what Ingersoll (2012) describes as the "greening" of the teaching force: the fact that an increasingly large segment of the teaching force is comprised of beginning teachers who are at a high risk of leaving the profession.

An accepted approach to ameliorating this problem is the implementation of induction programs, which serve to support beginning teachers over time through professional development, mentoring, and collaboration (Smith & Ingersoll, 2004). Induction programs have been promoted as a means to reduce teacher attrition, and research shows that quality induction programs (i.e. those that go beyond the simple provision of a mentor) do indeed improve teacher retention (Ingersoll, 2012; Smith & Ingersoll, 2004). This singular focus on the impact of induction programs on teacher retention has limited exploration of the potential of teacher induction programs to improve beginning teachers' instructional practices and student learning (Feiman-Nemser & Parker, 1990). Science-specific teacher induction programs can develop beginning teachers' capacity for inquiry-based and student-centered teaching strategies (Luft, Roehrig, & Patterson, 2003), but there is little research that investigates these particular supports and their role in developing reform-based practices in participating teachers. While teacher retention is critical, it is important at this time to look more deeply into the effect of teacher induction programs on promoting reform-based teaching practices for their new teacher participants.

This study investigates the Teacher Induction Network (TIN), an online induction program for beginning secondary science and mathematics teachers. TIN is structured to help beginning teachers not only survive their first two years in the classroom but also advance their professional growth towards implementing the reform-based science and mathematics classroom practices advocated for in the *Framework for K-12 Science Education* (NRC, 2012) and *Principles and Standards for School Mathematics* (National Council of Teachers of Mathematics [NCTM], 2000), respectively. In particular, TIN was designed to provide support for teachers who have completed a high-quality teacher preparation program, serving as a bridge to professional practice and building upon knowledge and practices from their pre-service program. This design extends reflection on reform-based practices into teachers' first school placements, as science teachers tend to revert back to traditional practices as they experience the reality of the classroom (Simmons et al., 1999).

Reflective practice is well established as central to the teaching and learning process of student teachers (Zeichner & Liston, 1987; Harford & MacRuairc, 2008), acting as a bridge between theory and practice through the integration of experience and reflection. Roehrig, Donna, Billington, and Hoelscher (in press) identified video annotation as a tool to promote beginning teachers' reflective practices. Our previous research (McFadden, Ellis, Anwar, & Roehrig, 2014) revealed that, with proper scaffolding and support from the instructor, video annotation provides beginning science teachers the opportunity to think critically on their own teaching practice. The current study extends our analysis of the use of video annotations by examining the technological and social affordances (Kirschner, Strijbos, Kreijns, & Beers, 2004) of the online video annotation tool through consideration of peer response annotations. The following research question guided this study:

> How do beginning teachers respond to a peer's initial annotations on his or her own teaching using a video annotation tool?

Supporting Literature

Within the classroom environment, teachers engage in a variety of tasks, from maintaining student engagement and sustaining lesson momentum to facilitating student learning. These actions create a continual array of dilemmas and choices with competing alternatives that require attention (Lampert, 2003). When considering the practice of teachers within the classroom, the use of video presents opportunities for promoting reflective practices not afforded prior to its inception and use in teacher education. The advantage of capturing video is simple: while teaching one cannot stop to reflect on their practice, but video enables the teacher to remove her/himself from the demands of the classroom and to step back and examine classroom events (van Es & Sherin, 2008). Given that teachers' knowledge is practical, personal, (Clandinin & Connelly, 1987) and contextualized (Brown, Collins, & Duguid, 1989), the opportunity to view oneself teaching has the potential to enable powerful reflection. Video then becomes a valuable means of supporting learning for teachers, as it facilitates the development of reflective practices, the examination of teaching from different perspectives, and the discussion of critical incidents and dilemmas (Le Fevre, 2004).

Teacher educators have used several video-based methods to promote teacher development. Two extensive reviews of the use of video in teacher education (Wang & Hartley, 2003; Brophy, 2004) reveal the predominance of video cases both as a practice and research focus in teacher education. In a review of the literature related to the use of video in teacher education, Sherin (2003) concluded that two affordances emerge when using video: (1) video allows for a permanent record of classroom occurrences that can be viewed repeatedly to ensure capture of classroom complexity and student-teacher interactions and (2) video provides the opportunity for teachers to develop an "analytic mind set" (p. 13). In a follow-up study, Sherin and van Es (2009) identified three primary research agendas for the use of video in supporting teacher learning: increasing pedagogical repertoire, developing content knowledge for teaching, and "learning to notice" important features of classroom interactions. Van Es and Sherin (2002) state that the development of reflective skills based on "learning to notice" important classroom events requires the analysis of video of one's own teaching within a familiar context.

Limitations in the Current Research

Existing research has focused on video reflection and teacher change through self-analysis (van den Berg, 2001; Brophy, 2004; Rich & Hannafin, 2009). Each of these studies maintained a focus on teacher self-analysis and did not consider the impact of peer feedback on video of teaching practice. While self-analysis is valuable for the beginning teacher, the knowledge that is built with one's peers is deemed most useful (Staver, 1998), and an understanding of how beginning teachers support one another through video reflection is equally necessary. However, research investigating the use of video in teacher education with groups of teachers interacting in communities of practice is scarce. Sherin and van Es (2005, 2009) identify video clubs as examples of teacher groups that view and reflect on video of themselves teaching. Harford, MacRuairc, and McCartan (2010) examined a similar video club model with twenty pre-service science teachers, wherein the participants viewed and discussed a wider selection of teaching episodes selected by their peers. These video clubs met in-person in a pre-service or professional development context in order to extend teachers' thinking about their own practice.

Research related to online video reflection in community is in its infancy. Rich and Hannafin (2009) described the variety of online video annotation tools available, and Rich and Tripp (2011) also set up guidelines as to how video annotation should be used. McFadden, Ellis, Anwar, and Roehrig (2014) explored beginning teachers' use of online video annotation tool; however, they focused on the annotations made by the teacher in the video without regard to the peer interactions. This research trajectory mirrors the trajectory of research on in-person video clubs, which first explored teacher self-reflection before considering the role of peer feedback in a community environment. Therefore, the next step in exploring online video reflection is to analyze the ways in which teachers support their peers through the use of online video reflection tools. Such work has the potential to support teacher educators in developing beginning teachers' reflective and reform-based teaching practices.

Theoretical Framework

National guidelines for teacher preparation and induction advocate the development of teachers as reflective practitioners (Council for the Accreditation of Educator Preparation, 2013). As we consider how participants in TIN reflect on their teaching practice, it is important to frame our work as researchers, instructors, and designers of this online environment (McKenney & Reeves, 2013) in the context of reflective practice. Dewey (1933) and Rodgers (2002) state that the primary objective of reflection-on-action is to promote the more difficult reflection-in-action. Reflection-in-action refers to the instantaneous response or action given in a situation as it unfolds in real-time (Schön, 1984). Reflection-on-action occurs after an event via a conscious and disciplined process ending with analysis of the experience and experimentation with possible methods of action (Zeichner & Liston, 1996; Rodgers, 2002). Video can aid in this process of reflection-on-action and allow the viewer to activate previously constructed knowledge (Eilam & Poyas, 2009). The act of viewing a video of oneself teaching provokes memory of a previous experience and provides opportunities for analysis and deliberation of possible future actions. Video annotation also challenges beginning teachers to move beyond a literal description of teaching events and think about why an event occurred. Van Es & Sherin (2002) refer to this phase as developing an argument and note the importance of providing evidence to support claims about the effectiveness of an event. Online video annotation in an induction program can provide beginning teachers the scaffolds they need to push teachers beyond describing what happened towards improving what will happen.

Methodology

Context

In order to explore the impact of teaching video on the reflective practice of beginning teachers, we turn to an online induction program called the Teacher Induction Network, or TIN. This program is part of the post-baccalaureate teacher preparation program at the University of Minnesota and is designed for beginning secondary science and mathematics teachers. The full teacher preparation program includes two components: initial licensure and completion of the M.Ed. degree. Pre-service teachers enter the 15-month initial licensure program as a cohort, completing coursework including a three-course subject-specific methods sequence with extensive, supervised practicum and student teaching experiences in both middle and high school settings. An additional 12-credits are required post-licensure to complete the M.Ed. degree, TIN is offered as a three-credit online course that fulfills part of this 12-credit requirement.

The four primary course assignments within TIN are Reflective Journals, Topical Response forums, Venture/Vexation discussions, and Professional Development Inquiries. These four assignment categories are described in detail in Roehrig, Donna, Billington, and Hoelscher (in press). The context for the use of video annotation and the data for this study are the Professional Development Inquiries (PDIs) that are detailed in this section, followed by a description of the video annotation tool.

Professional Development Inquiries (PDIs). The PDIs provide beginning teachers with an opportunity to investigate an area of concern or an area of their teaching that they would like to improve. Prior to starting each PDI, teachers complete a self-assessment using Danielson's Framework for Teaching (2007). Specifically, teachers were asked to evaluate themselves and identify areas for growth related to the five components of the instructional domain: communicating clearly and accurately, using questioning and discussion techniques, engaging students in learning, providing feedback to students, and demonstrating flexibility and responsiveness. In each PDI, teachers critically examine their own science teaching in relation to their beliefs and commitments and develop the skills of data collection, analysis and reflection. Thus, each PDI follows a reflective learning cycle in which the participants plan for action, implement their plan, and reflect on their actions, mirroring our theoretical framework for reflective practice.

After years of exploring various methods of accessing and viewing video from a distance (including mailing video cassette tapes), VideoANT was chosen as a web-based tool to more efficiently facilitate video reflection (http://ant.umn.edu). VideoANT is an internet-based, browser-embedded, video annotation software application that allows a user to add time-marked text annotations to a video of choice (Hosack, 2010). Figure 2.1 contains a screenshot of the software application in use. In VideoANT, a timeline is laid out across the bottom of the screen below the video clip that contains place markers where previous viewers have placed annotations. Annotations created by multiple users are displayed vertically down the right-hand column of the screen in alignment with the video being played for reading and response.

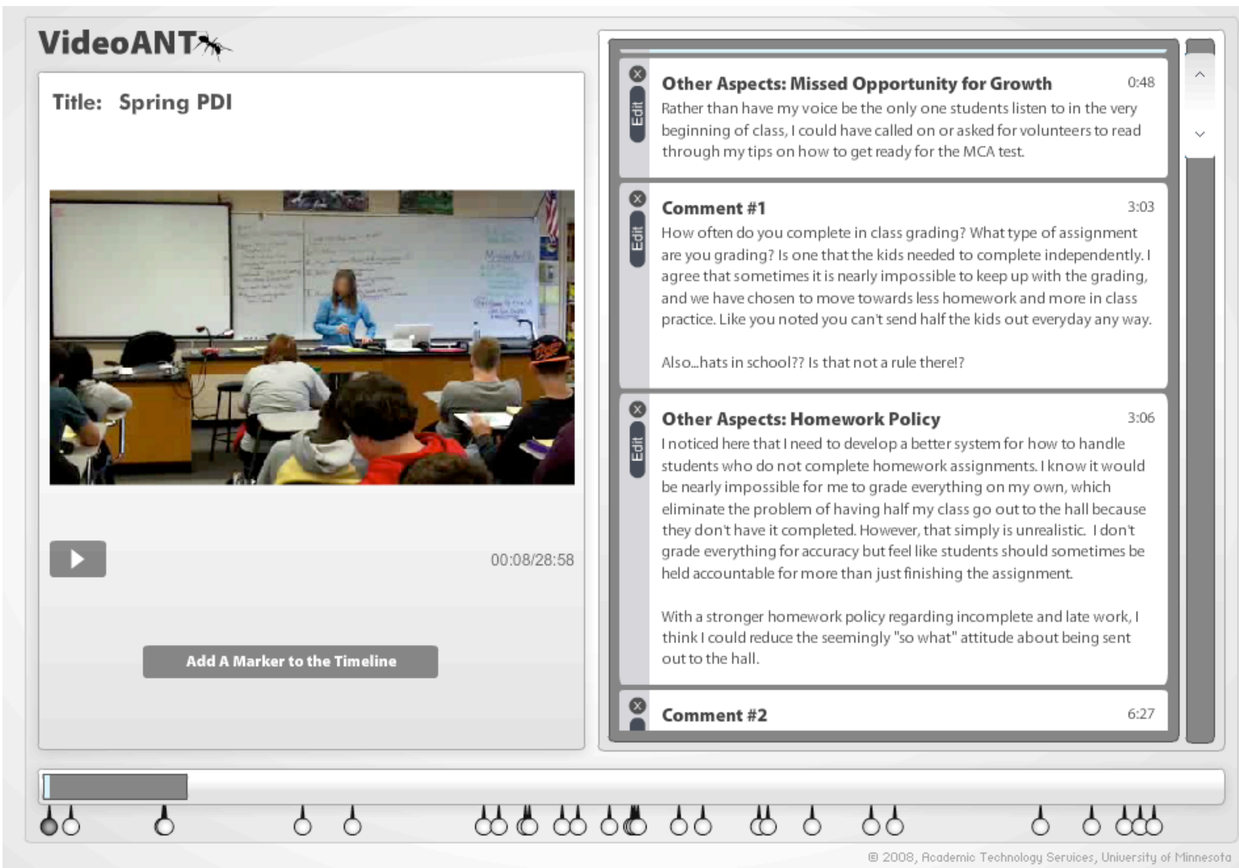

Figure 2.1. VideoANT screenshot of Edith.

As part of the PDI, beginning teachers were directed to upload 20 – 30 minutes of classroom video and use VideoANT to provide evidence of their professional growth based on their specific goal(s). After restating the goal(s) for the PDI in their first annotation, a minimum of five annotations related to the goal were required with a clear explanation of how the selected moments provided evidence of growth related to the instructional goal(s). Beginning teachers were also required to add at least 5 more annotations related to any other aspects of teaching practices that they noticed.

Following the initial annotation by the beginning teacher, a peer was directed to respond to either the initial comments or events not noted in the beginning teacher's initial annotations. Peers were directed to include a minimum of eight additional annotations and a final annotation at the end of the video commenting on their partner's progress toward their goal. Apart from this, peers were not directed to comment on specific elements of practice or respond in a certain way. This somewhat "hands-off" approach was intended to support the beginning teachers' development of self-efficacy while ensuring that crucial instructional elements were not overlooked. The purpose of this study is to explore the nature of the peer responses in the absence of explicit directives from the instructor-facilitator.

Methods

This study featured an interpretive case study design as defined by Yin (2014), which considers a single case (as opposed to multiple cases or control and treatment groups) and endeavors to reveal emerging themes and characteristics of the observed phenomena. In this study, the case is the group of TIN participants and the phenomena to be explored are the digital peer annotations made by TIN participants in VideoANT.

Participants

33 beginning secondary science and mathematics teachers were enrolled in TIN between the academic years of 2009 and 2011. The vast majority of these teachers were engaged in their first or second year of classroom teaching in Midwestern K-12 schools and enrolled in this course in partial fulfillment of their M.Ed. requirements. The criteria for participant selection included (1) a complete PDI including access to the beginning teachers' video and (2) the availability of extractable peer annotations from the video for coding and analysis. Following these guidelines, a total of 19 teachers were included in the study. Table 2.1 provides information on the 19 participants in this study. Participation in the study was voluntary, and the PDI was one of the primary graded course assignments in TIN.

Table 2.1. In-service teacher participants.

Teacher	**Gender**	**Year**
Daria	Female	2011-2012
Lanie	Female	2011-2012
Hank	Male	2011-2012
Erica	Female	2011-2012
Briane	Female	2010-2012
James	Male	2009-2010
Alec	Male	2009-2010
Cindy	Female	2009-2010
Kari	Female	2009-2010
Mason	Male	2009-2010
Chris	Male	2011-2012
Jenna	Female	2009-2010
Paul	Male	2010-2011
Morris	Male	2009-2010
Ben	Male	2010-2011
Cameron	Male	2010-2011
Bill	Male	2010-2011
Kathy	Female	2010-2011
Luke	Male	2010-2011

Data Collection

The data reported on here are digital peer annotations made by these 19 beginning science and mathematics teachers to their respective partners. Like themselves, their partners are developing their teaching practice by reflecting on their progress towards their PDI goal through the use of classroom video. VideoANT was used to share these videos and allow pairs of teachers to comment on their colleagues' progress while viewing the self-selected teaching episode. Partners were asked to *annotate responses to what your partner has noted or remarking on elements your partner has not noted*. An excerpt of VideoANT commentary between two partners is reproduced below:

> Luke: [14:01] This is something I like to do when teaching is involving the kids as much as I can, it helps them engage and learn form each other.

Briane: [14:08] Yes, involving the students as much as possible is so important. You will notice how quickly the students quieted down when a student is at the front of the room, and not just the teacher.

Luke: [18:43] By asking the class to help out [student] with the number of events I am trying to keep the whole class engaged, in case some students know that [student] is answering the question so they may check out. Same thing when [another student] comes up to answer the question.

Briane: [18:44] I agree that as soon as a student is called on, many student check out because they think they now don't have to do the thinking - somebody else is. When the student doesn't know the answer, I find it hard to pull the answer out of other students because they are also afraid to be incorrect. Including the whole class and getting all of them to think critically coming to a common answer is important in keeping everyone else engaged.

Each teacher was required to complete nine response annotations (eight related to events in the partner's video and one related to the partner's PDI goal). An example of teacher-pair responses is shown in Figure 2.1. These peer response annotations are the focus of this study.

Data Analysis

19 videos of classroom teaching, ranging from 11 to 21 minutes and containing a total of 174 peer response annotations, were collated and categorized. Of these 174 annotations, 167 related directly to the events in the video, while 7 were comments relating to technical difficulties or other subjects beyond the scope of the video. The

research team generated codes for peer response annotations inductively using constant comparative analysis (Patton, 1990). The five codes for peer response annotations identified in this study were (1) praise and or general agreement of the initial annotation or teaching practice observed, (2) providing a suggestion concerning the teacher's practice, (3) posing a question (open-ended or yes/no), (4) relating a teaching situation or initial annotation to one's own experiences, and (5) summarization of a partner's progress towards a goal. Table 2.2 presents these codes with their associated definitions and a brief example annotation that represents that code.

Table 2.2 Summary of identified codes.

Code	**Definition**	**Example Annotation**
Praise/Agreement	Approval of practice	What a great thing to do! You checked with another teacher as to the level of fairness of a test question. I like that a lot and try to do that as well (even though I often forget...) (Daria)
Suggestion	Recommendations for practice	While the students are up at the chalkboard writing, you could also be walking around and talking to you students here too. (Mason)
Question	Request for more information or inquiry into practice	How much time did you give to this project? Were they given as many attempts as needed in that time? (Paul)
Relate to Own Experience	Comparison of event to peer's prior experience	I like doing this too...it's worked well with my 9th graders this year. "Raise your hand when you know the answer but don't say anything..." (Alec)
Summarization	Commentary on teaching episode as a whole	It shows clearly that you have grown in your ability to engage students with questioning, simply from the engagement levels from the first few minutes to the last few minutes of this video. (Briane)

It is also important to note that a single peer response annotation could be coded more than once. For example, a peer response annotation may offer praise and agreement in response to the initial poster's commentary and also provide a suggestion regarding the event in question. An example of an annotation that was coded as both relating to one's own experiences and making a suggestion follows:

> Jenna: I don't know if you have used this before, but on the Vernier website there is a free download that I like to use when I'm introducing a lab using the Labquests. It lets you show what is on the labquest on your projector so they can see exactly what their screen should look like.

In this annotation, Jenna is responding to Morris' difficulties in setting up the lab for his students. She is sharing an experience that she had in her own classroom and suggesting that Morris might try the same. Following this scheme, the research team generated a total of 242 codes from 167 original peer response annotations.

Results

Statistical Analysis

In this section, the frequency and distribution of coded video annotation responses are presented. A frequency analysis was performed on the 167 unique annotations posted by peers within VideoANT. Figure 2.2 shows the frequency of the categories for the annotation responses, which total 242 codes (as some annotations were coded more than once). From these data, we find that annotations coded as praising and/or agreeing with one's partner form the relative majority (40.5% of total codes). With the exception of the summarization category, the three other response categories were represented relatively equally within VideoANT.

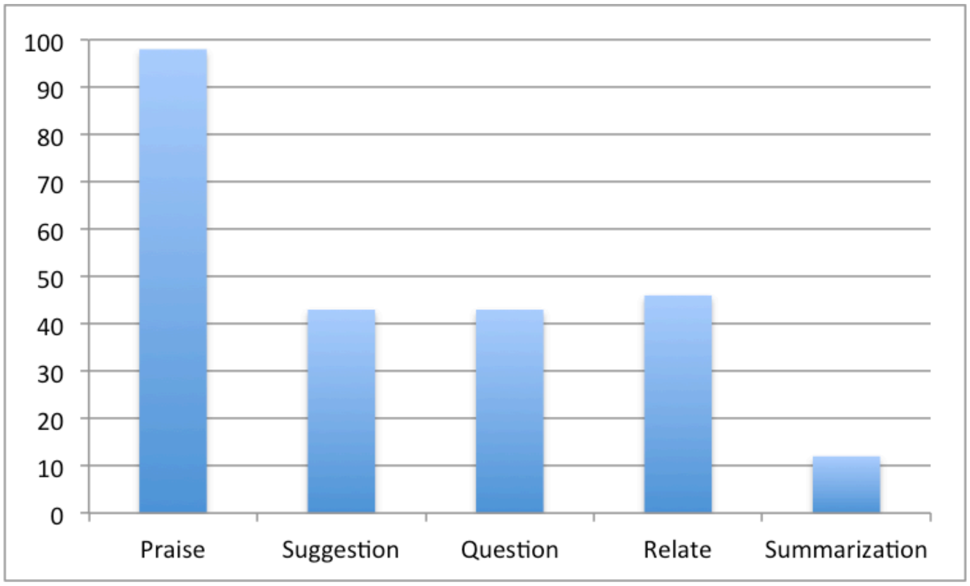

Figure 2.2 Frequency count of response annotations and associated response category.

After discovering a high preponderance of peer commentary classified as praise and agreement, we explored possible correlations between response type and three factors. The first factor we investigated was the gender of the peer. Secondly, we looked for differences in peer commentary between the three academic years that comprised this study. Finally, we explored whether the responses from specific individuals were statistically significant from one another. Each of these three factors was analyzed using a chi-square test of independence. The results of these analyses revealed no significant correlations between any of the three factors and response type. For differences by gender, $\chi^2(2, n = 242) = 1.74$, $p = .784$. For differences by academic year, $\chi^2(3, n = 242) = 11.20$, $p = .191$. For differences between individuals, $\chi^2(19, n = 242) = 77.60$, $p = .305$. Based on these results, we do not find any statistically significant correlations between gender and code frequency, year in TIN and code frequency, or individual peer and code frequency. This suggests that the distribution and frequency of codes are independent of these factors.

Exemplars and Interpretive Commentary

The following section provides exemplars of the generated codes, each followed by brief interpretive commentary.

Praise and/or agreement. Peer response annotations coded as *praise and/or agreement* often contained comments that expressed the responder's similar views on a given subject or approval of a practice in the initial post. Others extended into "pep talk" territory, where the peer would provide support to a colleague's initial annotation. For example, John, a chemistry teacher, performed and explained a demonstration to his class. His partner Kathy provided the following annotations:

> Kathy: Good recognition . . . and explanation. It was very clear the second time. Everyone in class hits it hard after that!
>
> Kathy: Good movement around the room. You make sure to see everyone in the classroom.

Both annotations indicate praise and agreement with what is occurring in the video, but this kind of commentary does not promote deep reflection that could potentially lead to a change in teacher beliefs or practices.

Providing a suggestion. This code was given to peer response annotations where the peer offered recommendations for the initial poster's teaching practice. These suggestions ranged from recommendations of online resources to suggestions about teaching strategies. For example, in a lesson dealing with acids and bases, Ben responds to Paul:

> Paul: [I] probably should have actually written that acids are below 7 and bases are above. [I] will need to fix that.
>
> Ben: Referencing stuff they've used in class helps connect the knowledge, and helps w/ the engagement factor. It's not something someone might think of, but every bit helps.
>
> Ben: I'd relate HCl being the same as stomach acid. Might not hurt to put a picture too, for those that remember through picture learning along with the words.

In this example, Ben supports Paul by providing a suggestion for future teaching situations. Paul concluded that a simple summary of the pH scale would have sufficed. Ben agrees that grounding current work in prior knowledge is helpful, and he goes on to suggest a technique for increasing student engagement by relating the content to previous experiences in class as well as a real-life example. This suggestion could serve to extend Paul's thinking and provide him with a new strategy for when a similar situation arises again.

Posing a question. Annotations coded as *posing a question* demonstrated the responder's attempts to elicit more information about the event or push the initial poster to think more deeply about what transpired in the video. In some cases, both of these elements were present within a single annotation. An example of a questioning peer response annotation follows:

> Jenna: Did you notice a big difference in just general confusion during the lab? How well do you think the second class did just figuring out for themselves how to use the materials given? I think you mentioned this in a previous post, but how did you decide which class would get the cookbook lab and which would get the inquiry?

While some peer questions are posed in response to an annotation from the initial poster, this question here is an example of the peer noticing events in the video that the initial poster had not addressed. As this example shows, posing a question can push the initial responder to compare situations, reflect on student direction, and think critically on actions in the lesson that they had not yet reflected on.

Relating to one's own experience. These peer response annotations drew comparisons between the experience of the initial poster and the peer's experience in their own teaching practice. In some cases, this comparison would be followed by the peer *making a suggestion* or *posing a question*. For example, Erica's partner Chris responds to her frustrations about her use of rhetorical questions and students' inability to analyze data and diagrams. His commentary regarding the use of Process Oriented Guided Inquiry Learning (POGIL) provides an example of a peer response annotation that was coded as both *relating to one's own experiences* and *providing a suggestion*:

> Chris: Yeah this is always a tricky thing to lead students on a pathway of questions to elicit the correct response. We have done some of this in the form of POGIL's....it is a worksheet/packet type activity, but it walks the kids through step by step objective questions about a diagram (much like those in the presentation)

> to more abstract and application type questions. It might be another tool to start your kids moving in that direction. It is also a good group/pair activity, and you get some good discussions. Hard to do in lecture format though. I think you are tied to the white board...is there any way you could guide student writing within the presentation?? This is a tough thing though too, because they struggle to do two things at once such as writing and questioning or writing and listening."

Peers like Chris may have felt that their suggestions would be better received if they demonstrated that they had experienced similar situations. However, not all annotations with this code necessarily led to a question or suggestion; many peers simply expressed their solidarity or understanding of a success or challenge in the video.

Summarization. This code was given to annotations that provided commentary on the video as a whole instead of on a particular event. The annotations that were made in relation to the partner's PDI goals frequently fell into this category. These annotations would wrap up the commentary that came before, usually occurring at the end of the video. For example, after reviewing his partner's video and making annotations that related to specific events or questions, Cameron summarizes at the end of the video:

> Cameron: I feel that you met the primary objective of providing timely feedback to students by being mobile in the classroom during this lab activity. I saw many examples of good evidence showing that you were very present as a resource for your students. Nice work-

By their nature, these annotations rarely referred to events happening at the time of the annotation itself, as was the case with the other annotation codes. Instead, these annotations served the instructor-facilitator's requirement for a final annotation at the end of the video commenting on their partner's progress toward their PDI goal.

Discussion

Beginning teachers face a wide array of challenges during the starts of their careers, and video clubs provide teachers the opportunity to continually reflect on and analyze their practice (Sherin & van Es, 2005, 2009). The ability to work with partners and colleagues within VideoANT affords teachers the opportunity to struggle together (i.e. relate to their own experience), further analyze their teaching practice (if asked a question), and receive suggestions and guidance as they navigate obstacles in their first few years in the classroom. The video annotation activities embedded within TIN align with the views of Dewey (1933) and Rodgers (2002) relating to the development of reflective practitioners in the classroom. Furthermore, the emphasis on collaboration (Dewey, 1933; Rodgers, 2002) is maintained despite the potential challenge of facilitating the course completely online. However, these results suggest that the mere presence of an online video club is not enough to encourage beginning teachers to reflect on their practice critically. Instead, the relative majority of peer commentary praises and affirms the practices of these teachers, and commentary that would probe deeper into teacher practice and offer alternative solutions is less frequent.

This issue is particularly problematic in the context of an induction program. Luft, Roehrig, and Patterson (2003) demonstrated that induction programs can promote inquiry-based and student-centered teaching strategies. It is possible but unlikely that peers' praise and agreement is directed towards beginning teachers' enactment of these strategies; indeed, the bulk of praise/agreement commentary is in response to classroom management and behavioral issues. Within TIN, we desire for beginning teachers to develop their "analytic mind set" (Sherin, 2003) and define the bridge between theory and practice through reflective practice (Zeichner & Liston, 1987; Harford & MacRuairc, 2008), but this is not possible when peers praise one another regarding non-reformed teaching practices. The fact that many peers do engage in critical commentary demonstrates that VideoANT is capable of supporting reflective and analytic discussions around beginning teacher practice. However, these results indicate that supports are needed to increase reflective commentary in this environment among beginning teachers.

Conclusions and Implications

The intent of the VideoANT activity in TIN is to provide teachers with an affordance for reflecting on past teaching practice by sharing and commenting on a video of their instruction. The purpose of doing so is to allow teachers to explore their successes and struggles, identify elements of their teaching that contribute to those successes and struggles, and elicit feedback from peers that may guide the teacher towards improving their practice. However, without explicit direction regarding the nature of the commentary, peers respond most frequently with praise and agreement, neither of which supports teachers in improving their practice. On the contrary, this kind of commentary may actually confirm and entrench current practices and inhibit the pursuit of new ways of teaching. For example, there is one likely outcome of Kathy's simple statement of *praise and agreement*: John continues to teach as he has taught in the past without questioning his teaching practices or decisions. Praise and agreement cannot lead to a teacher reforming his or her teaching practice; it can only confirm and entrench the teacher's current practice. As the purpose of TIN is to promote the development of teacher practice, this effect can in fact be detrimental to beginning teachers. Additionally, a preponderance of praise may potentially lead to frustration as a new teacher is being told their practice is fine while they continue to struggle. In short, being nice could actually hinder teacher development and lead to continued frustration in the classroom.

The results of this study indicate that specific, explicit supports for teacher discourse in VideoANT are needed in order to foster the reflective practice that course designers and instructor-facilitators desire. Within VideoANT, this may take the form of requirements regarding the nature of peer feedback commentary. Based on the codes generated in this study, we intend to generate a set of guidelines for beginning teachers to consult as they provide feedback to their peers' videos of teaching practice. These guidelines would not only increase teacher awareness of the purpose of the VideoANT activity, but also formally guide them as they practice providing substantive feedback to their peers and receiving it in kind. Such explicit supports for reflective commentary may prove valuable in other TIN activities where reflective practice is developed through other means, including individual reflective journals and problem-solving group forums.

Limitations and Future Work

There are a handful of small but important limitations associated with this study. First, the context of this study is a single course at a Midwestern institution, where many of the participants had also enrolled for their initial teaching licensure. The effects of participation in the licensure program on teacher performance in TIN have not been explored. A second consideration is that two different instructors led TIN during the span of time encompassed by this study. Although we did not observe a statistically significant difference in response types between years, there may be other effects associated with different teaching styles and strategies enacted by the instructors.

Video and its place within science teacher education are becoming more established as new technologies and opportunities for learning and reflection emerge. As researchers and instructors in TIN, we are actively seeking ways to positively change the course design in order to promote science teacher development. By conducting and reporting on the trials and tribulations of such endeavors, we hope to place future science teacher educators in an elevated position with the knowledge to improve their course design and enhance their tool selection to better guide the development of beginning science teachers in the field. A future research avenue in this online induction environment could explore the relationships between teacher posts and peer responses in VideoANT annotations. McFadden, Ellis, Anwar, & Roehrig (2014) considered how teachers used VideoANT to reflect on video of their own teaching. In this study, we have investigated how these teachers' peers provide feedback through VideoANT. While it has been beneficial to investigate these two kinds of video annotation separately, future work might consider possible relationships between the nature of the initial posts from the teacher and the responses that the peer provides. For example, do more reflective initial posts influence the nature of the peer responses? Does the subject of the initial post have an effect on the reflective nature of the response? Work that explores questions such as these could shed light on the factors that influence teachers to respond more critically and provide more support to the teachers that are eliciting commentary on their teaching practice.

CHAPTER 3

STUDY 2

Introduction

In response to the nationwide demand for science teachers in K-12 education (National Commission on Excellence in Education, 1983; National Research Council [NRC], 2007), teacher preparation programs have been successful in preparing new science teachers to keep pace with the increase in demand (Ingersoll & Merrill, 2010). However, with 50% of these new teachers leaving the profession within their first five years of teaching, districts struggle with a “revolving door” phenomenon (Smith & Ingersoll, 2004). In response to this challenge, the education community has responded by implementing induction programs, which serve beginning teachers through support, guidance, and orientation (Smith & Ingersoll, 2004). These induction programs have been hailed as an effective strategy for not only improving teacher retention but also teacher job satisfaction and efficacy (Smith & Ingersoll, 2004). Unlike other professions, the teaching occupation does not boast an established, structured process of initiation into the profession. Opportunities for teachers to participate in in-service training, such as professional development and workshops, do exist. However, induction programs provide coherent, targeted support for beginning teachers who are most at risk for leaving the school or the profession.

While many studies have focused on the ability of induction programs to improve teacher retention, few focus on the ability of induction programs to develop the practice of the participants through mentoring and collaboration. Roehrig, Donna, Billington, and

Hoelscher (in press) call for research that investigates the impact of induction programs on teacher practice and self-efficacy, and an important component of teacher practice is the ability to reflect on that practice (Dewey, 1993; Rodgers, 2002). Killion and Todnem (1991) define reflection as a vehicle for developing context-specific theories that inform future practice, which is well aligned with the goals of teacher induction programs. Our previous work has shown that beginning teachers in an online induction program struggle to reflect deeply and critically without specific, targeted supports for reflective dialogue (McFadden, Ellis, Anwar, & Roehrig, 2014). Therefore, this study explores the ability of a designed intervention to support beginning teachers' reflective practices in an online induction program.

Theoretical Framework

Reflective Practice

Reflective practice is well established as being central to the teaching and learning process of beginning teachers (Zeichner & Liston, 1987; Harford & MacRuairc, 2008). Teachers who engage in reflective practice bridge the gap between theory and practice through an integration of experience and reflection. Both Dewey (1933) and Tickle (2000) note the importance of reflective practice as a way for teachers to actively engage with problematic situations. This engagement with problems of practice involves both reflection-on-action and reflection-in-action. Dewey (1933) states that the primary objective of reflection-on-action is to promote the more difficult reflection-in-action, which refers to the instantaneous response or action given in a situation as it unfolds in real-time (Schön, 1984). Rodgers (2002) defined reflection-on-action as a conscious and disciplined process that occurs after an experience and ends with analysis of that experience and experimentation with possible courses of action. This view is rooted in Dewey's (1933) three stages of reflection-on-action: *description, analysis,* and *action*. Description refers to the observation of the experience (where ideas are articulated but interpretations are held at bay), analysis refers to the process of generating possible explanations, and action is a considered step forward based on experience (Rodgers, 2002). Within the context of classroom instruction, a teacher can engage in *description* and *analysis* of his or her teaching practice after the fact. The following *action* occurs when the teacher returns to the classroom and implements the new or modified teaching practice that will then be reflected on moving forward. This form of reflective practice is the hallmark of a master teacher, and takes many years to develop.

One way to support teacher development of reflective practice is through mentoring and collaboration. Smith and Ingersoll (2004) identify mentoring as a hallmark of induction programs, where personal guidance is provided to beginning teachers. Mentoring is an intrinsically valuable practice for the development of beginning teachers. Smith and Ingersoll (2004) note that, in addition to improving teacher retention, mentoring also has the potential to improve the job satisfaction and efficacy of teachers. However, mentoring in other professions is often directed towards developing the practice of novices. One approach toward building novice knowledge and expertise through collaboration with more experienced professionals is the creation of a community of practice. Zeichner and Liston (1987) and Wenger (1998) describe communities of practice as groups of people who improve their practice through mentoring and collaboration with one another, sharing knowledge for the purpose of increasing the skills of novices in the community. The following literature review will serve to situate the current study with respect to knowledge regarding communities of practice and teacher leadership.

Literature Review

Communities of Practice

In order for teachers to develop their practice in meaningful ways, they must situate themselves within a community of practice (Zeichner & Liston, 1987) where they can reflect on their experiences and bolster their knowledge in conjunction with their peers. Communities of practice are composed of people who engage in collective learning in a shared domain of interest (Wenger, 1998), such as teachers in an induction program. Staver (1998) notes that when knowledge is built in conjunction with one's peers, it is deemed useful by those involved. The activities of communities of practice can vary widely; problem solving, seeking information or experience, and discussing new developments are all examples of activities that members of a community of practice can engage in to advance their practice (Wenger, 1998). Harford and MacRuairc (2008) present an example of a community of practice within the context of a 1-year teacher education program for student teachers. This community was centered on learning in the shared domain of K-12 teaching and engaging in meaningful reflective practice, and participating student teachers "demonstrated tangible evidence of the development of reflective skills working in the context of a community of practice" (p. 1890). Examples such as this demonstrate the value of communities of practice in promoting reflective practices among beginning teachers.

Due to limitations of time and space, a community of beginning teachers cannot always meet face-to-face. However, an online environment provides opportunities for such practitioners to engage in community when geographical distance or time would otherwise be a barrier to interaction. In *Building Online Learning Communities,* Palloff and Pratt (2007) strongly support the use of collaborative practices and other forms of community-centered instruction in online environments to promote what they describe as reflective or transformative learning. This kind of learning "moves a student from someone who takes in information to a reflective practitioner involved with the creation of knowledge" (p. 51). Palloff and Pratt (2003) also note that both collaborative learning and reflective practice are necessary in order for reflective/transformative learning to occur. These observations underscore the importance of both reflective practice and communities of practice in an online community devoted to reflective learning.

A challenge with online learning compared to face-to-face learning is the difference in participation expectations. While students in a traditional classroom may arrive before class, socialize, and gather in small groups without prior planning, students in an online classroom do not have the opportunity to bump into one another, read facial expressions and body language, or experience participation in the same way as a face-to-face classroom (Palloff & Pratt, 2007). Researchers and instructors have therefore wished to explore the dynamics of online groups. One measure of group dynamics is called group cohesion, defined by Haythornthwaite (1996) as the extent to which all members of a group interact with all other members. This is important in an online community of practice, as higher group cohesion is indicative of teachers interacting with all members and sharing knowledge in a distributed way. It is also indicative of participants establishing their online social presence and taking ownership of their online community (Palloff & Pratt, 2007).

Teachers as Leaders

One approach to promoting collaboration, cohesion, and reflective practice among teachers is through teacher leadership. New views on leadership within science education have been taking shape over the course of nearly two decades. Shanker (1987) identified the need for teachers to become leaders within their schools and communities of practice without abandoning their classrooms. Katzenmeyer and Moller (1996) defined a view on teacher leadership where teachers "lead within and beyond the classroom" (p. 6) with fellow teacher leaders. In a review of the literature, Howe and Stubbs (2003) synthesize a perspective on teacher leadership that arises from and is created by a community of practitioners. "This is a view of leadership that is not managerial or administrative but is one of leadership exercised within the community of practice to which the leader belongs" (p. 284). This view of leadership is highly compatible with the theory of communities of practice, and it is fitting for a community that is composed of novice practitioners. Instead of leaders who are seen as being more experienced or elevated above those they lead, we can imagine a community of teachers who help to lead each other as they collectively develop their teaching practice.

Dempsey (1992) defined four “images” for teacher leadership that can help guide those new to teaching, leadership, or both. These images are teacher as *scholar,* teacher as *reflective practitioner,* teacher as *partner in learning,* and teacher as *fully functioning person*. Each of these images represents a different facet of teacher leadership: the scholar leverages knowledge from academic research communities, the reflective practitioner looks back at past practice before considering future action, the partner in learning helps to deconstruct a colleague’s challenge before offering a solution, and the fully functioning person looks outward to the greater context of the classroom. These images form the basis of a nascent conceptual framework that advances a view of leadership development extending beyond simple skill learning. With support, teachers can adopt these images when responding to situations or thinking critically on an event in the classroom or the school.

Limitations in the Current Research

To date, there is little literature that explores the promotion of leadership roles among beginning teachers and its effect on those teachers’ reflective practice. While Sherrill (1999) identified the utility of teacher leadership in the context of teacher induction, she reserved the teacher leadership role to more experienced teachers who would mentor and coach the beginning teachers. In a review of the literature, York-Barr and Duke (2004) chart an evolution in teacher leadership away from concentrating leadership responsibilities in the hands of senior educators and towards recognizing the capacity for all teachers to demonstrate leadership in their classrooms and schools. However, the dimensions of practice that have been explored in connection to teacher leadership pertain to management, collaboration, school change, and other district-level outcomes (York-Barr & Duke, 2004). The relationship between teacher leadership and reflection on the teacher's own practice, on the other hand, has not been documented. Therefore, the purpose of this study is to explore the impact of promoting teacher leadership on the reflective practice of teachers in an induction program.

The Study

Context

The Teacher Induction Network (TIN) is an online induction program for beginning secondary science and mathematics teachers. TIN is part of the post-baccalaureate teacher preparation program at a large Midwestern university. The teacher preparation program includes two components: initial licensure and completion of the M.Ed. degree. Pre-service teachers enter the 15-month initial licensure program as a cohort, completing coursework including a three-course subject-specific methods sequence with extensive, supervised practicum and student teaching experiences in both middle and high school settings. An additional 12-credits are required post-licensure to complete the M.Ed. degree, and TIN is offered as a three-credit online course that fulfills part of this 12-credit requirement. TIN is structured to help beginning teachers not only survive their first two years in the classroom but also advance their professional growth towards implementing reform-based science and mathematics classroom practices advocated in the *Framework for K-12 Science Education* (NRC, 2012) and *Principles and Standards for School Mathematics* (National Council of Teachers of Mathematics

[NCTM], 2000), respectively. This design provides an extension of reflection on reform-based practices developed to overcome socialization in school, as science teachers tend to revert back to traditional practices as they experience the reality of the classroom (Simmons et al., 1999).

The four primary course assignments within TIN are Reflective Journals, Topical Response forums, Venture/Vexation discussions, and Professional Development Inquiries. These four assignment categories are described in detail in Appendix A. The Venture/Vexation activity is the primary focus of this study and is described in detail in the following section.

The Venture/Vexation activity. This structured response activity is adapted from the work of Johnston and Settlage (2008) as a way to provide critical feedback within a small-group setting. A single presenter in the group shares either a Venture (a desire to try something new) or a Vexation (a situation that is challenging) with the rest of the group via an online forum post. Peers then elicit more information from the presenter in the form of clarifying questions, and the presenter answers these questions if possible. After receiving clarification from the presenter, peers then provide feedback or suggestions regarding the presenter's venture or vexation. The activity concludes with final remarks from the presenter. The entire activity takes place over the span of one month, and a new presenter begins the activity in each successive month. The timeline for these events is represented in Table 3.1.

Table 3.1. Timeline of Venture/Vexation events.

Day of Month	Presenter Duties	Peer Duties
Between 1st and 7th	Define the venture or vexation	None
Between 7th and 18th	Read peer questions and respond	Ask clarifying questions of the presenter
Between 18th and 21st	State a plan for action based on peer feedback	None
Before end of month	None	Comment on plan for action

While the Venture/Vexation activity was originally intended as a face-to-face discussion, enacting this activity online in a forum-based environment within TIN has some advantages. The online environment is "quiet" in comparison to a face-to-face setting (Palloff & Pratt, 2002), giving participants time to craft thoughtful responses and provide higher-quality feedback. Each Venture/Vexation activity spanned an entire month, giving the presenter time to lay out the issue and allowing his or her peers time to open up and explore the Venture or Vexation.

Design Intervention: Teachers as Leaders Roles

In an effort to promote more reflective commentary within the Venture/Vexation activity, teachers enrolled in TIN in Year 8 (2013-2014) were asked to adopt a leadership role when writing as a peer in the Venture/Vexation activity. While the task of the presenter was unchanged, teacher peers were asked to respond "in character" to the venture or vexation of the presenter as either the *scholar, reflective practitioner, partner in learning,* or *fully functioning person*. These roles rotated month to month in order to allow each participant to exercise each of the roles throughout the academic year. In order to assess the impact of this intervention, this study will compare the

Venture/Vexation interactions when the Teachers as Leaders roles were present (Year 8) to the interactions from the previous year (Year 7) when the roles were not present. The research questions that guided this comparison study are:

RQ1: What is the impact of Teachers as Leaders roles on group cohesion in the Venture/Vexation activity?

RQ2: What is the impact of Teachers as Leaders roles on level of reflection in the Venture/Vexation activity?

Methods

This comparison study employed a co-relational *ex post facto* approach as defined by Cohen, Manion, and Morrison (2013), where differences in an independent variable are compared to differences in one or more dependent variables. In this study, the independent variable is the presence or absence of Teachers as Leaders roles and the dependent variables are group cohesion and level of reflection. The data under consideration include the Venture/Vexation interactions from Year 7 (where no Teachers as Leaders roles were present) and the Year 8 (where Teachers as Leaders roles were incorporated). Through this comparison, we can assess the effect of the Teachers as Leaders roles intervention on group cohesion and level of reflection. The first research question regarding group cohesion in the Venture/Vexation activity is addressed through both visual and quantitative methods of analysis. The second research question regarding level of reflection in Venture/Vexation commentary is addressed through qualitative analysis.

Participants

Participants for this study include 34 beginning secondary science and mathematics teachers in their first or second year of teaching between the academic years of 2012 and 2014 (n=14 for Year 7, n=20 for Year 8). Most of these teachers were teaching in Midwestern K-12 schools and enrolled in TIN for partial fulfillment of their M.Ed. requirements. These teachers were placed into one of four collaborative groups for the entire academic year. Group size ranged from three to five teachers, with four being the most common. Each group participated in six Venture/Vexation activities throughout the year.

Analysis

Data collection and analysis are described separately for each of the two research questions. To address the first research question, we engaged in SNA to assess group cohesion in all Venture/Vexation activities for Years 7 and 8. To document evidence of the second research question, we used deductive coding to assess the level of reflection in all Venture/Vexation activities for Years 7 and 8. The details for each of these analyses follow.

RQ1: Group cohesion. The visual and quantitative means of analysis for this research question find their roots in social network analysis (SNA). Through SNA, patterns of relationships between actors can be developed in order to represent how information flows in a network (Haythornthwaite, 1996). This technique has found particular utility in the social sciences, where researchers relate differences in network patterns to differences in outcomes (Borgatti, Mehra, Brass, & Labianca, 2009).

Researchers of online learning environments identify SNA as a leading method for the study of online social interactions, especially in learning networks (Gruzd, Haythornthwaite, Paulin, Absar, & Huggett, 2014). One application of SNA is to assess elements of participant group cohesion in a collaborative online learning environment (Dawson, Bakharia, & Heathcote, 2010), and SNA is therefore an ideal technique to evaluate the cohesiveness of an online group.

This study assesses group cohesion via a quantitative measure called *network density*, which is defined as the ratio of the number of actual links in a group to the number of possible links in a group (Haythorthwaite, 1996). In the Venture/Vexation activity, network density is calculated as the number of posts made in reply to a peer divided by the number of peers one could reply to. The software tool SNAPP (The University of Queensland Australia, 2011) was used to calculate network density for each of the 48 Venture/Vexation activities. The purpose of analyzing group cohesion in the Venture/Vexation activity is to test whether or not the inclusion of Teachers as Leaders roles had an impact on network density, which would indicate if knowledge was distributed within the group or highly concentrated.

RQ2: Level of reflection. In addition to the analysis of the group structure, we considered the individual forum posts themselves. This qualitative analysis consisted of coding each Venture/Vexation post occurring in Year 7 and Year 8. In a review of the literature, Larrivee (2008) identified four distinct levels of teacher reflection: 1) *pre-reflective* commentary is characterized by non-reflective (or “knee-jerk”) responses, 2) *surface* reflective commentary focuses on resources and strategies to reach predetermined goals and discover “what works” in the classroom, 3) *pedagogical* reflective commentary makes connections between teaching theory and teaching practice, and 4) *critical* reflective commentary considers the moral, ethical, social, and/or political implications of teacher practice. After reviewing the Venture/Vexation activity, Polizzi, Dean, Barrett, and Rushton (2014) modified the Larrivee rubric for teacher reflection by adding a fifth level of reflection called *technical.* Placed between the surface and pedagogical levels of reflection, this type of reflective commentary features reflection on teaching techniques without considering underlying theory or causes. Technical commentary may suggest changes and solutions that focus on short-term results without consideration of long-term effects. In total, the rubric allows raters to score reflective commentary on a five-point scale, as indicated in Table 3.2.

Table 3.2. Rubric developed by Polizzi et al. (2014) for assessing reflective commentary in the Venture/Vexation activity.

Level	**Factors**
Pre-reflection	Fails to reflect on the topic in any way
Surface	Operates in survival mode, reacting automatically without consideration of alternative responses
	Enforces preset standards without adapting or restructuring based on responses
	Does not support beliefs and assertions with evidence from experience, theory or research
	Is willing to take things for granted without questioning
	Is preoccupied with management, control, and student compliance
	Fails to recognize interdependence between teacher and student
	Views student and classroom circumstances as beyond the teacher's control
	Attributes ownership of problems to students and others and see themselves as the victim
Technical	Limits analysis of teaching practices to technical questions and teaching techniques
	Modifies teaching strategies without challenging underlying assumptions about teaching and learning
	Fails to connect specific strategies to underlying theory
	Makes adjustments based on past experiences
	Reacts to student responses differentially, but fails to recognize patterns
	Adjusts teaching practices only to current situation without developing a long term plan
	Implements solutions to problems to problems that focus only on short term results
	Questions the utility of specific teaching practices but not general policies of practices
Pedagogical	Analyzes the relationship between teaching practices and student learning
	Strives to enhance student learning for all
	Seeks ways to connect new concepts to students' prior knowledge
	Has genuine curiosity about the effectiveness of teaching practice,

	leading to experimentation and risk-taking
	Engages in constructive criticism of one's own teaching
	Adjusts methods and strategies based on students' relative performance
	Analyzes the impact of task structures (cooperative learning groups, partners, peer or other groupings) on student learning
	Searches for patterns, relationships and connections to deepen understanding
	Identifies alternative ways of representing ideas and concepts to students
	Recognizes the complexity of classroom dynamics
	Acknowledges what a student brings to the learning process
	Sees teaching practices as remaining open to further investigation
Critical	Views practice within the broader sociological, cultural, historical and political contexts
	Considers ethical ramifications of classroom policies and practices
	Addresses issues of equity and social justice that arise inside and outside the classroom
	Challenges the status quo norms and practices, especially with respect to power and control
	Is aware of incongruence between beliefs and actions and takes action to rectify
	Is an active inquirer, both critiquing current conclusions and generating new hypotheses
	Challenges assumptions and expectations of students
	Suspends judgments to consider all options
	Acknowledges that teaching practices and policies can either contribute to, or hinder, the realization of a more just and human society
	Encourages socially responsible actions in their students

Using this rubric, all 615 Venture/Vexation interactions from both academic years were deductively coded in order to assess the level of reflection of each post. To test for inter-rater agreement, two raters independently coded 107 interactions sampled at random from the 615 total interactions. Analysis of the raters' scores using the five-point rubric yielded a Cohen's weighted kappa of $\kappa = 0.72$, indicating substantial agreement (Viera & Garrett, 2005). As a result, the two raters went on to divide the remaining 509 interactions randomly and independently score them. To test for differences in the distribution of codes between Year 7 and Year 8, a Mann-Whitney U-test was performed. This non-parametric test is used with ordinal data to determine if a variable is observed more frequently in one of two groups (Sheskin, 2007). If the Year 7 and Year 8 distributions of codes are found to be significantly different, a visual analysis of the distributions will be used in order to assess the difference.

Results

RQ1: Group Cohesion

Density network analysis. To compare the 48 Venture/Vexation conversations, measures of network density were used. Table 3.3 reports the calculated network density of each Venture/Vexation activity from Year 7 and Year 8 as well as the mean network density and standard deviation for each Venture/Vexation group. It is important to note that network density is normalized with respect to network size, as a larger group with many interactions could have the same network density as a smaller group with proportionally fewer interactions. Therefore, it is appropriate to compare the network density calculations of groups that vary in size.

Table 3.3: Network density of Venture/Vexation activities.

Group	VV 1	VV 2	VV 3	VV 4	VV 5	VV 6	Mean (SD)
Year 7							
Ocelot	1.10	1.83	0.90	0.70	1.45	1.25	1.21 (0.40)
Giraffe	0.80	1.17	0.65	0.50	0.60	0.60	0.72 (0.24)
Platypus	1.50	1.00	0.83	0.83	0.67	0.92	0.96 (0.29)
Yak	1.25	1.83	0.83	0.75	0.92	1.58	1.19 (0.44)
Total							1.02 (0.39)
Year 8							
Aardvark	0.65	0.70	1.00	0.85	0.85	0.40	0.74 (0.21)
Elephant	0.65	0.70	0.75	0.90	0.65	0.65	0.72 (0.10)
Nightingale	0.40	0.25	0.42	0.55	0.60	0.40	0.44 (0.12)
Vulture	0.65	0.45	0.90	0.92	0.35	0.67	0.66 (0.23)
Total							0.64 (0.20)

A two-sample t-test was performed between Year 7 activities (n=24) and Year 8 activities (n=24). The results indicate a highly statistically significant decrease in the mean network density from Year 7 to Year 8, with $t(46) = 4.28$ and $p<.001$. Since the only change between the two years was the inclusion of Teachers as Leaders roles, this may indicate that Teachers as Leaders roles are in fact inhibiting group cohesion in the Venture/Vexation activity. Instead of promoting a free and open discourse with multiple group members, the scaffolding from this intervention may have actually served to limit teacher discourse within the group; teachers in Year 8 posted less frequently and interacted with fewer group members compared to teachers from Year 7 where the intervention was not present. However, this observed decrease in the quantity of posts as a result of Teachers as Leaders roles does not represent the quality of those interactions. It is critical to also consider the nature of the posts, not just the quantity. This was accomplished through coding and analysis of the content of the Venture/Vexation posts in order to assess any differences in level of reflection between Year 7 and Year 8.

RQ2: Level of Reflection

After coding all 615 April Venture/Vexation posts from both years (n=333 from Year 7 and n=282 from Year 8), a Mann-Whitney U-test was performed to determine any difference between the Year 7 and Year 8 distributions of reflective codes. The test found a highly statistically significant difference in the distributions of codes, with $p<.001$. As stated before, the function of this test is to reveal if there is a difference in the overall distribution of ordinal data between the two years. To determine the nature of the differences for each level of reflection, a visual inspection of the data is required. We therefore performed a frequency analysis on these coded posts and represented the distribution of all posts from both years in Figure 3.1. This visual analysis is complemented below by brief exemplars of each observed code with interpretive commentary.

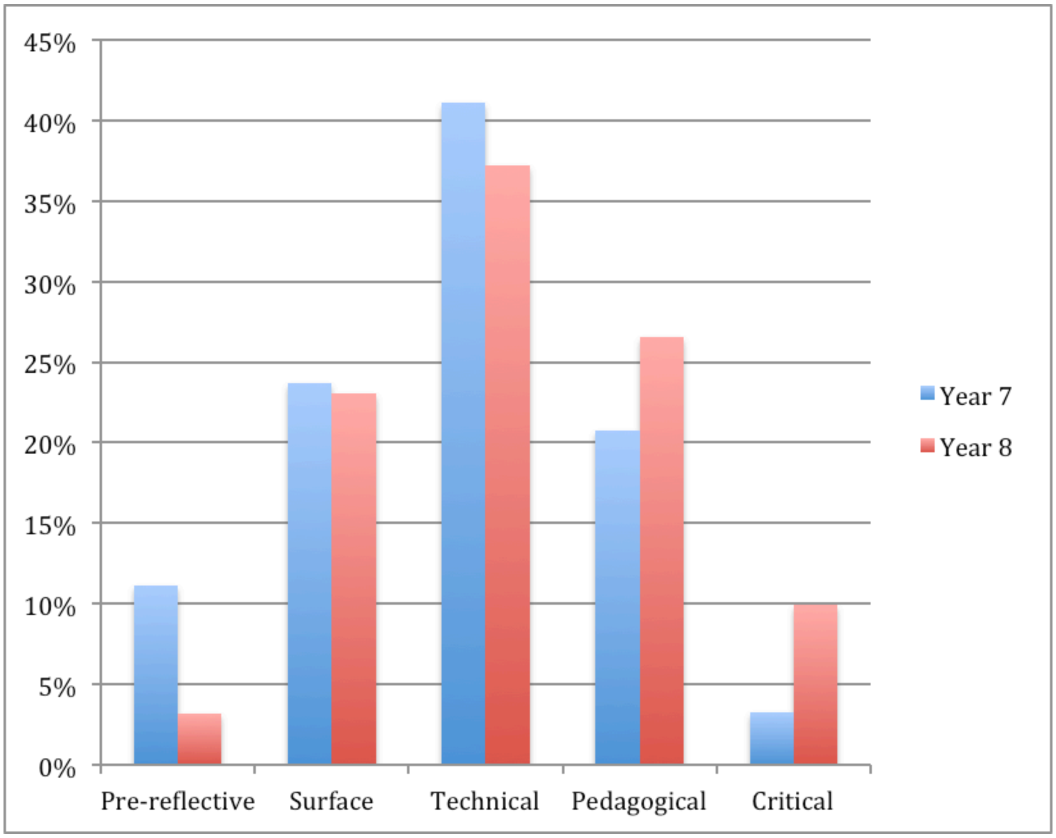

Figure. 3.1: Frequency count of Venture/Vexation posts and associated reflective level.

Pre-reflective. Pre-reflective commentary is defined by Larrivee (2008) as “knee-jerk” responses that are not reflective in nature. Examples of Venture/Vexation posts that were coded as pre-reflective follow:

> Group Yak (Mar Y7): That's a very good idea. I will ask my students to that. thank you
>
> Group Ocelot (Apr Y7): I plan on talking to the fifth grade teacher soon. Standby.
>
> Group Aardvark (Feb Y8): will you please reply to my question today? The Venture/Vexation timeline says I must post suggestions by today in response to your questions.

These examples demonstrate how some teachers make posts that provide short updates to their peers or communicate their thanks for an earlier comment. However, these teachers did not continue on to provide reasons for their statements, such as why they were planning to talk to the 5th grade teacher or what in particular the liked about the idea that was shared with them. We observed a large difference in frequency of pre-reflective commentary between Year 7 and Year 8, with 11.1% of all Venture/Vexation commentary for Year 7 being classified as pre-reflective and only 3.2% of all commentary in Year 8 being classified as such. As the goal of the Teachers as Leaders roles was to increase the level of participant reflection, this marked reduction in pre-reflective commentary is seen as a positive result.

Surface. Surface commentary is defined by Polizzi et al. (2014) as reflection that focuses on the short-term goals. Teachers who reflect at the surface level are operating in "survival mode" and often preoccupied with management, control, and student compliance. They may also view circumstances relating to their students or their classroom as beyond their control as a teacher. Examples of surface commentary follow:

> Group Giraffe (Feb Y7): being in two different buildings really is a hard context in which to build relationships and even a common school culture. Will your school be moving to one location any time soon

> Group Vulture (Feb Y8) That sounds like an awesome idea!...Much easier. Just have to make sure my students buy into it!

> Group Aardvark (Jan Y8): 40 minute classes! That is short!…What procedures do you currently have in place for lab set-up and clean-up (with a shared classroom)? What type of clean up is required? What currently takes students the most time to tidy?

These examples show that teachers are reflecting on the situation but focusing on short-term solutions or solutions that are outside of the teachers' control. Teachers in both Year

7 and Year 8 exhibited a nearly identical amount of surface commentary (23.7% and 23.0%, respectively).

Technical. This category was defined by Polizzi, Dean, Barrett, and Rushton (2014) after a thorough review of the Venture/Vexation activity. They believed that a significant amount of commentary was occurring that went beyond surface reflection but fell short of pedagogical reflection. Technical reflection was therefore defined as reflection that focused on techniques and strategies. This kind of reflection can lead to a teacher modifying their practices based on past experiences, but these strategies are not grounded in an underlying theory. Technical reflection may also question the utility of specific practices without questioning the policies of those practices. Examples of technical commentary follow:

> Group Vulture (Jan Y8): Wow, this is quite a pickle!...Do you have any PARAs [paraprofessionals] for your classes with the heaviest amount of SPED [special education] students? From what it sounds like to me, your SPED teachers are doing more finger pointing than helping. They should be in this with you to help get these students going. It might be worth asking if they could do some schedule switching to get one into your toughest hour.
>
> Group Yak (Mar Y7): I love the idea of having students use phones to document their experiments, set-up, et cetera during class! It seems like a great way for us to get an inside look into ALL of our students class experiences! Recently, the science teacher at my school had students complete an assignment where they made a short video explaining the mitosis. I wonder if cell phones could do the same?
>
> Group Nightingale (Apr Y8): For this one student, and her couple of friends, I would reccomend {sic} private conversations that focused on how you care about their future success and the importance of showing respect towards others and finding appropriate ways to voice concerns. If the conversation becomes heated, stay on message and don't get dragged into any power struggles squabbling over particulars. Set clear expectations for her behavior going forward, with clear and actionable consequences. Then do everything you can to check in with her some time during the day BEFORE your next class with her starts to express the fact

> that each day is a new day, you are excited for her to be back in your class, and that you look forward to a good day.

Compared to surface commentary, these technical posts feature more probing questions and more robust strategies. Further, the suggestions are supported with explanations that provide some rationale for why this strategy might work. The relative majority of commentary in both Year 7 and Year 8 was coded as technical (41.1% and 37.2%, respectively).

Pedagogical. Commentary that connected theory to practice was coded as pedagogical. Such commentary often considered the relationship between teaching practices and student learning, and suggestions at this reflective level were centered on being responsive to student needs. Examples of pedagogical commentary follow:

> Group Ocelot (Nov Y7): Another suggestion would be to have the students read the paper on their own as homework. They must chose at least three difficult terms and define them as well as take notes on the main ideas through webbing or whatever method you have taught them. Then, when they come to school the next day, post your questions on the board and have them think-pair-share. That would allow students to read at their own pace to get familiar with the article.

> Group Elephant (Dec Y8): I really like that you grade the formative assessments each day and give the students feedback. Is there a way you can structure the questions or the assessment that will allow you to grade them quicker? I am glad that [group member] mentioned students grading each other's works, I think we often do not let students see how other students make mistakes (or do it right). One thing I have incorporated into my class are response systems. These allow me to do quick quizzes that I then can import right into my grading system, requiring very little work from me. I am not sure if you can do this judging you are in several classrooms but perhaps there is a way you can do it electronically/quicker.

These posts show how teachers are asking questions and providing suggestions at a higher reflective level compared to surface or technical reflection. Theories about cooperative learning and formative assessment are brought to bear on these particular challenges, and teachers are emphasizing the importance of accurately assessing student needs and pacing the classroom accordingly. Teachers in Year 8 exhibited a higher percentage of pedagogical reflection (26.6% of total) when compared to Year 7 (20.7% of total).

Critical. This is the highest level of reflective commentary, where teachers consider the ethical and social implications of their teaching practice (Larrivee, 2008). Teachers who reflect critically in the Venture/Vexation activity address issues of equity inside the classroom and challenges assumptions and expectations of students. An example of critical commentary follows:

> Group Aardvark (Mar Y8): Thanks for giving me more insight about the group work you are using in your lessons. This month, I am going to take on the role of the scholar. I found a fairly comprehensive article (see attached) which talks about the elements which must exist in a classroom in order to have effective group work. After discussing the history of group work in the mathematics classroom, the article describes how a classroom must have a culture of collaboration and teamwork in order to maintain good group work. That is, students must trust each other. This trust should be built through deliberate interactions and activities which break down social barriers. These activities should be incorporated into the classroom throughout the year, rather than just at the beginning of the year.

These teachers are demonstrating sensitivity to differences in student ability as well as access. Their questions and suggestions are focused on creating opportunities for students, and some of the suggestions begin to challenge the status quo and reach for new ways to address differences in student learning within the classroom and beyond. We observed a large difference in critical commentary between Year 7 and Year 8, with only 3.3% of total posts from Year 7 being coded as critical compared to 9.9% of total posts in Year 8. While critical commentary is still infrequent, this result suggests that the inclusion of Teachers as Leaders roles contributed to the threefold increase in critical commentary between Year 7 and Year 8.

In summary, both the statistical analysis and a visual inspection of Figure 3.1 reveal a shift in the distribution of reflective commentary between Year 7 and Year 8. This shift suggests that Teachers as Leaders roles may encourage teacher-participants to push their feedback into higher-order questioning and commentary with their colleagues. This is most noticeable in the large reduction of pre-reflective commentary and large increase in critical commentary in Year 8. From these results, it is clear that teachers are capable of engaging in higher-order commentary when provided with the appropriate scaffolding.

Conclusions

Based on these findings, a number of conclusions can be drawn regarding the effect of Teachers as Leaders roles on the online Venture/Vexation activity in TIN. While the inclusion of the Teachers as Leaders roles inhibited group cohesion, it also stimulated teachers to engage in higher-order reflection when participating in this activity. The positive result is that increased scaffolding from instructors regarding reflective practice and commentary is found to be beneficial for beginning teachers to frame their discussions about challenges and explorations within their own classroom. The outcomes of the Venture/Vexation activities after the Teachers as Leaders intervention are in line with the goals of Dewey (1933) and Rodgers (2002) for using reflection on past experiences to inform experimentation with new solutions. This result also confirms the recommendation of McFadden et al. (2014) to include targeted supports for teachers' reflective practice, as less reflective commentary occurs in the absence of such supports.

However, the negative result suggests that the use of such supports may come at the cost of an organic social network where teachers experience frequent interactions with all their peers. The value of frequent interactions is not directly addressed in the literature surrounding communities of practice; Wenger (1998) notes the importance of community members defining a group identity surrounding the practice to be explored, but does not make any claims about how, with whom, and how frequently those members must interact. An organic and conversational network, while perhaps desirable, is not strictly necessary for our community of practice. However, Haythornthwaite (1996) notes that groups with low density (such as those who adopted the Teachers as Leaders roles) can struggle with having knowledge concentrated in the hands of a few individuals. This would contradict our current view on teacher leadership where we desire all participating teachers to demonstrate leadership (York-Barr & Duke, 2004). In the case of the Venture/Vexation activity, the presenter in a group with low density was often the "information broker" where interactions were concentrated. Since a different individual served as the presenter each month, we were less concerned about this result and did not observe a handful of individuals dominating the group interactions repeatedly.

Implications

These mixed findings in this study present a dilemma for the designers of TIN: is the increased higher-order commentary worth the cost of a cohesive social network in the

Venture/Vexation activity? At this time, it is the opinion of the authors that the benefits of Teachers as Leaders roles outweigh the drawbacks. There are two primary reasons that inform this belief. The first is that there was a significant increase in higher-order commentary in Year 8 compared to Year 7, which was a primary goal of the Teachers as Leaders intervention. The second is that the Venture/Vexation activity is not designed to emulate a normal social network. Instead of a network of peers that flows with information, the Venture/Vexation activity is a highly structured, albeit somewhat artificial, discussion forum where problem-solving is paramount. Vonderwell (2003) notes that students in online question-based discussion forums like the Venture/Vexation activity see these networks not as places for social interactions, but for the sharing of ideas. For these reasons, we may prioritize the value of the Venture/Vexation activity as an incubator for reflective practice and not as a network for social interactions.

These findings are of particular relevance to instructors of online or hybrid courses who wish to promote critical thinking, reflective commentary, and communities of practice among their participants. Online induction programs are powerful tools for promoting not only teacher retention but teacher development as well, and our study explores the impact of a leadership intervention on group dynamics and reflection on teaching practice in our online forum environment. We find that the use of Teachers as Leaders roles in the Venture/Vexation activity positively impacts the ability of teachers to reflect more deeply on their teaching practice. As we continue to design and refine activities within TIN, studies such as this are critical in making informed decisions regarding the current and future instruction of beginning teachers as they embark on their journey towards becoming reflective practitioners.

Limitations and Future Directions

There are a small number of important limitations inherent in this study. The first is the inability to account for what we will call *implicit connections* made by teachers in the Venture/Vexation activity. While we can analyze *explicit* connections made in the form of forum posts and replies, we cannot easily assess how teachers learn from simply reading what others have written. This is similar in some ways to *lurking*, a term defined by Nonnecke and Preece (2000) as the activity of an online participant who posts only occasionally (if at all) but reads the group's postings frequently. A future study that focuses on this phenomenon might consider interviewing teachers to ascertain how the Venture/Vexation activity informed their understanding in ways that were not expressed directly in the forum activity.

Another limitation of this study lies in the limited exploration of factors related to higher reflective commentary in the Venture/Vexation activity. While we found a statistically significant increase in reflective commentary as a result of the Teachers as Leaders roles, there exists the possibility of covariates that may more directly account for the change. Some potential covariates include the topic of the Venture/Vexation activity, the reflective level of the first post, and possibly the presenter themselves. A more thorough statistical analysis would be required in order to assess the potential existence of such covariates.

CHAPTER 4

STUDY 3

Introduction

Researchers have begun to craft specific recommendations for the integration of technology within science education. Flick and Bell (2000) suggest that science educators must take advantage of the unique features of technology, use technology to make scientific views more accessible, and develop an understanding of the relationship between science and technology. Hughes (2005) claims that teachers must have a technology-supported pedagogy and skills base in order to effectively integrate technology into their instruction. An accepted framework for defining the role of technology in education is the Technological Pedagogical Content Knowledge Framework, or TPACK (Mishra & Koehler, 2006; Koehler, Mishra, Akcaoglu, & Rosenberg, 2013). This framework has been used to assess the capacity for pre-service teachers to effectively integrate technology (Schmidt et al., 2009; Hechter, Phyfe, & Vermette, 2012) and to better understand pre-service teachers' perceptions and awareness of TPACK (Hechter & Phyfe, 2010; Hechter, 2012). However, there is little literature that explores the effect of targeted interventions on improving pre-service teacher understanding of TPACK.

Many teacher preparation programs include coursework on technology integration to guide future science teachers to use technologies applicably in science classroom settings (Hughes, 2005), develop a personal understanding of technological affordances and limitations based on research and experience (Kirschner, Strijbos, Kreijns, & Beers, 2004), and create a vision for teaching and learning science with technological support (Hechter & Vermette, 2012). As pre-service teacher understanding of TPACK is essential in the pursuit of these goals, we wished to explore the impact of targeted instructional interventions within a technology integration course on increasing pre-service teacher understanding of TPACK. The intervention featured in this study is teacher participation in the creation of an Adventure Learning (or AL) environment (Doering, 2006) for use by future students and educators. The research question for this study is:

> **RQ:** How does pre-service secondary science teachers' understanding of TPACK change after participating in the creation of an Adventure Learning environment?

Literature Review

Technology Integration

In the context of STEM integration, significant focus has been given to engineering integration in recent years (National Research Council, 2013; Moore et al., 2014). By comparison, technology is the STEM discipline with the least formalization and operationalization of knowledge within the context of K-12 education. Calls to address this gap have been made for over 25 years, starting most prominently with the Project 2061 Technology Panel (Johnson, 1989). Thornburg (1999) identified four pillars for a national plan regarding technology in education: 1) modern learning devices will be accessible to all students, 2) classrooms will be connected to other classrooms around the world, 3) educational software will be an integral curriculum component, and 4) teachers will be prepared to teach with technology. Sadly, few of these goals have been realized in part, if at all; in a review of the literature, Hew and Brush (2007) note that there still exist significant barriers to technology integration, especially with regard to the availability of digital resources and the knowledge and skills of teachers using this technology.

Hughes (2004) calls for teacher education programs that create *technology integrationists* - teachers who possess “the unique ability to understand, consider, and choose to use technologies *only* when they uniquely enhance the curriculum, instruction, and students’ learning (p. 346).” In order to make these explicit connections between technology integration and student learning, groups of individuals from the same subject area often gather to share their strategies for technology integration, either formally (as part of a professional learning community or professional development activity) or informally (through conversations with colleagues, both in-person and online). Hughes (2005) finds that these subject-specific technology inquiry groups promote content-based technology pedagogy, while instruction that focuses solely on the technology results in technology pedagogy that fails to make connections to content. Therefore, in order to create a community that promotes technology-integrated instruction that serves both content and pedagogy, we must draw upon a framework that explicitly relates content, pedagogy, and technology for instruction.

Technological Pedagogical Content Knowledge Framework

Discussions about how to meaningfully integrate knowledge about content, pedagogy, and technology have led to the creation of the Technological Pedagogical Content Knowledge Framework, or TPACK (Mishra & Koehler, 2006; Koehler, Mishra, Akcaoglu, & Rosenberg, 2013). While TPACK is a relatively young construct, its roots lie in Shulman's (1986) conception of pedagogical content knowledge, or PCK . In addition to content knowledge, Shulman identified the existence of *pedagogical content knowledge (PCK)*. More than the sum of content and pedagogical knowledge, PCK is the practical knowledge of how to transform content into learning experiences for students (Shulman, 1986). A teacher with strong PCK knows how to represent content for the purposes of teaching, address common student conceptions and misconceptions relating to content, and attend to students' learning needs within the classroom (Rowan et al., 2001).

By the 2000s, technology occupied an increasingly visible and useful role in education. The proliferation of computers and other digital tools within the classroom made many aspects of teaching more efficient and convenient. However, these tools were not yet being used to support learning in the way that Thornburg (1999) described. In response, science and mathematics educators sought new ways to prepare future teachers for the new landscape of K-12 education. Niess (2001) claimed that science and mathematics teachers could not meaningfully integrate technology as tools for learning until they learn what it means to teach with technology. This requires a new way of thinking about teacher knowledge that goes beyond the PCK of Shulman. Niess (2001) described this updated construct as technology-enhanced PCK, or TPCK.

Others saw the advent of educational technology as a signal to extend the work of Shulman. Although Shulman did not directly address the role of technology in education, Mishra and Koehler (2006) felt that powerful analogies and representations of subject matter (techniques identified by Shulman as hallmarks of PCK) were directly achievable through the application of technology in the classroom. They defined technological knowledge (TK) as knowledge about not only technologies themselves (such as blackboards, the internet, and digital video), but also the skills require to operate those technologies. As Shulman (1986) sought to end the separation of content and pedagogical knowledge, Mishra and Koehler (2006) proposed an end to the exclusion of technological knowledge from PCK with the formalization of TPCK. In this new model (depicted in Figure 4.1), there are now four areas where the knowledge bases overlap, and each area represents a unique form of knowledge: PCK, which can be found in Shulman's original framework; TPK, which addresses how technologies are used in specific educational settings; TCK, which identifies the relationship between technology and the content it supports; and TPACK, which represents the appropriate and context-specific strategies for technology integration (Mishra & Koehler, 2006). This framework is suitable for use in pre-service or in-service settings as a tool to guide educators in their meaningful integration of technology with content and pedagogy.

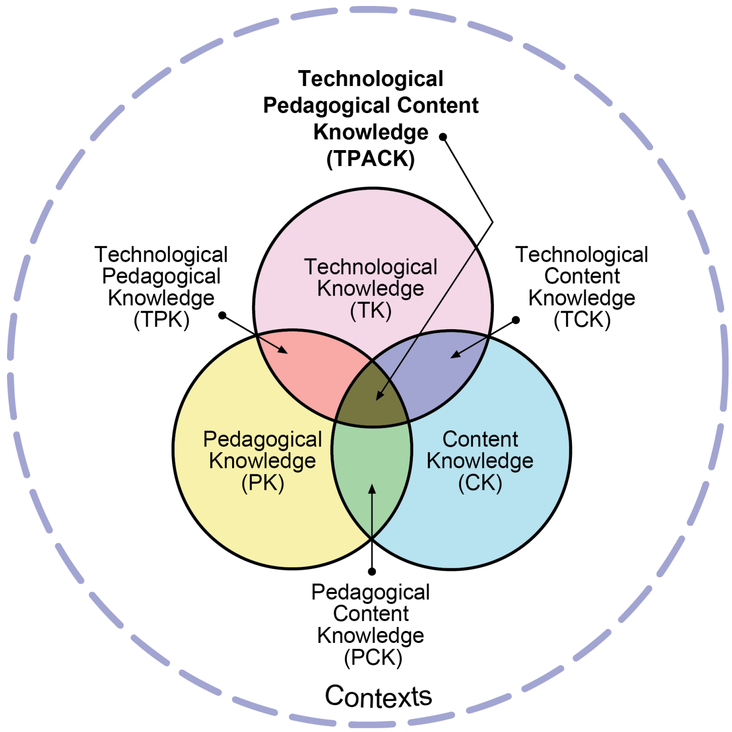

Figure 4.1: Model of the TPACK framework as proposed by Mishra & Koehler (2006).

Application of TPACK to Teacher Education

There are a small number of studies that specifically address the utility of TPACK in improving technology integration for pre-service and in-service science teachers. Habowski and Mouza (2014) demonstrated that "a content-specific technology integration course offered simultaneously with extensive field experience through careful instructional design can improve pre-service teachers' understanding of combining technology with science content and pedagogy" (p. 471). This finding suggests that pairing content-specific technology integration instruction, as described by Hughes (2005), with field teaching experiences can improve how pre-service teachers understand TPACK. Hechter & Vermette (2014) reveal that in-service K-12 science teachers choose to integrate technology in order to promote student engagement, teach 21st century skills, improve teaching practice, stay current with technology, and enable hands-on interactive learning. This suggests that in-service teachers value technology integration for its ability to promote student-centered strategies such as increased engagement and interactive, participatory learning. A primary goal of coursework in technology integration is to engage pre-service science teachers in a subject-specific, content-based technology pedagogy as described by Hughes (2005) so that they are capable of engaging in technology-integrated instruction in the ways that Hechter & Vermette (2014) describe. Therefore, an understanding of how specific activities within a technology integration course promote pre-service teacher understanding of the role of TPACK in science instruction is required.

Methodology

Context

Technology integration has been a hallmark feature of the University of Minnesota's science teacher licensure program. Pre-service teachers are required to complete the course Technology Tools for Teachers (T^3) concurrently with their first field teaching experience. This course, offered through the Learning Technologies academic program to all content areas, is designed to engage pre-service teachers in the explicit integration of technology and teaching practices. The course is subdivided into sections by content area, and pre-service science teachers take a section created exclusively for secondary science educators (T^3-S). This section is designed to guide pre-service secondary science teachers in thoughtfully integrating technology within research- and standards-based science instruction for the purpose of enhancing student learning of science content.

The Fall 2014 T^3-S course featured a blended (or hybrid) course design that incorporated both in-person and online modes of instruction and learning, allowing pre-service teachers more flexibility in participating in the learning environment while increasing their exposure to technological strategies through their own learning. These pre-service teachers met in-person every two weeks and completed online activities between these face-to-face meetings. The course syllabus is included as Appendix B. As previously stated, the teachers were simultaneously engaged in a middle school field teaching experience. Pre-service teachers partnered with an in-service teacher to observe his or her instruction, support the in-service teacher's instruction, and lead instruction themselves for small curricular units that the pre-service teachers designed. Their efforts to integrate technology into these "mini-units" were often the subject of conversation in T^3-S.

Within the University of Minnesota's science licensure program, instructors present technological affordances as a way to model and explore difficult science concepts, support student inquiry, and clarify and display student thinking. The goals for T^3-S include pre-service teacher facility with 1) using technologies applicably in science classroom settings, 2) developing personal understanding of technological affordances and limitations based on research and experience (Kirschner, Strijbos, Kreijns, & Beers, 2004), and 3) creating a vision for teaching and learning science with technological support. This study focused on a specific intervention within T^3-S, called Adventure

Learning, that was designed to promote teachers' understanding of the role of TPACK in science instruction.

Design Intervention: Adventure Learning

Doering (2006) defines Adventure Learning, or AL, as an approach that allows students to engage in relevant issues through authentic distance learning experiences through collaborative online learning environments. AL is most often delivered in a hybrid online educational environment that connects students, teachers, and content experts who would otherwise not interact with one another in a face-to-face setting. One example of such a partnership is the Arctic Transect project, where six educator-explorers traveled across the Canadian Arctic by dogsled and interfaced with students from local tribal villages and around the world (Doering, 2007). These students collaborated with the educator-explorers and one another on learning projects related to the live expedition. AL that occurs in Arctic Transect and other projects is grounded in pedagogies that provide students with encountering discrepant events (activities that require students to develop a deep understanding of content in order to participate effectively) and the use of technologies that afford interaction with phenomena and persons that the student would otherwise never have access to (Doering, 2009). As these AL pedagogies are well aligned with TPACK principles, we wished to study the effect that engagement in an AL experience had on the development of pre-service teachers' TPACK.

Pre-service teachers enrolled in T^3-S in Fall 2014 participated in an AL experience wherein they co-created lesson plans, instructional strategies, and an online learning environment for Chasing Aurora, a nascent AL project. Developed by Hechter &

MacDonald (2015), Chasing Aurora is designed to promote astronomy learning through expeditions to Canadian locations in the “auroral zone,” a geographic region where the *aurora borealis* and other astronomical phenomena are particularly visible. Researchers, teachers, and students would participate in the project by designing investigations for the educator-explorers to conduct and collaborating synchronously through videoconferencing or asynchronously through email. In order to bolster these collaborative and communicative elements, the leaders of Chasing Aurora wished to create an online learning environment for the project, and this initiative became the goal of the AL module for pre-service teachers in T^3-S.

During one face-to-face class period, each pre-service teacher in T^3-S joined one of three groups, each tasked with a specific creative purpose: *Sirius* was tasked with developing a curriculum unit that was compatible with the astronomy education goals of Chasing Aurora, *Antares* researched and documented the cultural contexts of astronomical phenomena and lore from a wide range of cultural backgrounds, and *Polaris* integrated the digital tools and activities that would facilitate communication and collaboration between students, teachers, and researchers in Chasing Aurora. Group members worked within and across their groups to reach the creative goals described above, collaborating with other groups as they deemed necessary. All pre-service teachers were also provided with editing access to the Wordpress content management system that would become the online home of Chasing Aurora.

Methods

This study ascribed to an explanatory embedded multiple-case study methodology as proposed by Yin (2014). The cases for this study were the three AL teams: Antares, Polaris, and Sirius. The embedded unit of analysis was the individual pre-service teacher candidates. As the purpose of the study was to understand the effect of an adventure learning experience on pre-service science teachers' TPACK, each AL team formed a single case for analysis. The survey responses of participants in those teams were analyzed in order to explain the effect of the learning interventions on the participants (Figure 4.2).

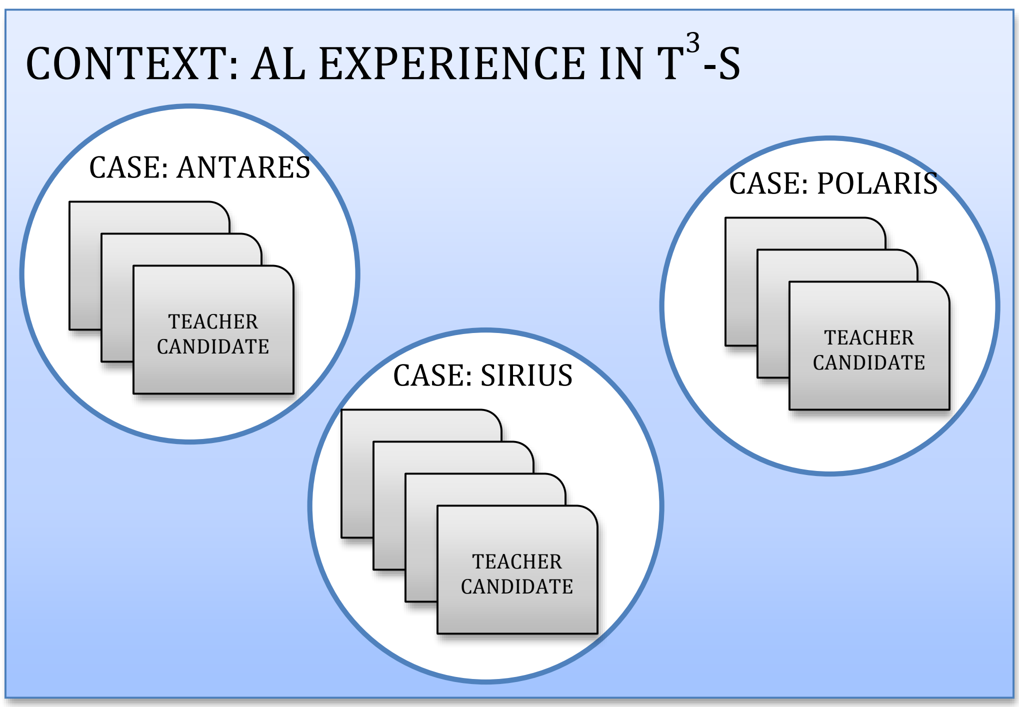

Figure 4.2. The embedded multiple-case study design, adapted from Yin (2014).

Participants

This study considered ten pre-service science teacher candidates enrolled in T^3-S. Of the eighteen teachers enrolled in the course, ten had provided consent to participate in the study and completed all three course questionnaires used in this study. These ten teachers were composed of 5 males and 5 females representing biology (n=4), chemistry (n=3), and physics (n=3) content areas. Each teacher chose to join one of the following AL teams: Antares, Polaris, or Sirius (see Table 4.1).

Table 4.1. Pre-service teacher participants.

Teacher	Gender	Content Area	AL Team
Bonnie	Female	Biology	Antares
Charles	Male	Chemistry	Antares
Kevin	Male	Biology	Antares
Lisa	Female	Physics	Polaris
Kristine	Female	Biology	Polaris
Marc	Male	Physics	Polaris
Andrew	Male	Chemistry	Sirius
Geoffrey	Male	Biology	Sirius
Sarah	Female	Biology	Sirius
Yang	Female	Physics	Sirius

Data Collection and Analysis

Data sources. Three data sources were used in this study. The first data source was a TPACK Questionnaire that was administered prior to the AL experience. The prompts in this questionnaire were based on those used by Hechter (2012):

1. What is your understanding of the relationship between technology, content knowledge, and pedagogical knowledge in the context of science teaching?
2. How will you incorporate aspects of this relationship into your science teaching?

The second data source was an AL Pre-questionnaire that was administered before teachers participated in the AL experience. The prompts were:

1. We will be engaging in an adventure learning experience in this course. How do you think this will impact your understanding of TPACK?
2. What impact do you think this experience will have on your science teaching?

The third data source is an AL Post-questionnaire that was administered after the AL module. Those prompts were:

1. Think back to the adventure learning module. How did this experience impact your understanding of TPACK?
2. What impact did this experience have on your science teaching?

In between the AL Pre-questionnaire and Post-questionnaire, teachers engaged in the creation of the AL environment as described earlier.

Analysis. Pre-service teacher responses to each questionnaire were openly coded (Strauss & Corbin, 1990), and the resulting codes from each questionnaire were collapsed into categories and themes via thematic analysis (Miles & Huberman, 1994) in order to identify common themes and ideas among course participants. These themes were subjected to constant-comparative analysis (Strauss & Corbin, 1990) in order to validate their relevance.

Results

In our analysis, we did not find significant differences between the three cases in any of the questionnaires. There did not appear to be any unique relationship between teacher responses to the questionnaires and the group that they participated in. Therefore, the resulting themes will be presented below and categorized instead by data source.

TPACK Questionnaire

Theme 1: Balance within TPACK. When asked about the relationship between technology, content knowledge, and pedagogical knowledge, teachers overwhelmingly identified the need to integrate aspects of TPACK in a balanced way. Teachers described technology as a necessary ingredient for student learning, and that all three elements (technology, content, and pedagogy) must be interrelated, integrated, and balanced in order to create the best learning possibilities. Teachers believe that "there is a happy medium between teaching, content, and technology (Geoffrey)" and this balance "makes our teaching practice more comprehensive (Lisa)." However, this balance is often "complicated and intertwined (Kristine)," making it difficult to define where one domain ends and another begins. Yang suggested that "technology, content knowledge, and pedagogical knowledge prompt each other...Pedagogical knowledge guides a teacher how to teach the content knowledge; technology scaffolds the teaching and learning of content knowledge." Teachers believe that this balanced and synergistic relationship, when realized in the classroom, opens up the greatest potential for student learning.

Theme 2: Technology as support for student learning. Teachers indicated that technology should serve and support the content objectives of the lessons; in some cases, technology "allows them [the students] to dig deeper into content (Charles)" through increased scaffolding. Andrew mentioned, "we need to understand how to teach the concept and how to use the technology in relation to the concept." Kevin elaborates, "I consider a teacher's technological knowledge...his or her understanding of how to use technology to facilitate students' learning and exploration of science content and nature of science principles." These teachers identify the role technology plays in elucidating conceptual ideas, and they see themselves "using technology to try to convey some of the more abstract principles (Marc)." Therefore, the use of technology must be purposeful.

Kristine says, “It’s important that when technology is implemented in the classroom, it meaningfully contributes to the students’ understanding of the content.” As teachers begin to integrate technology into their instruction, they will only do so when that technology affords their students increased understanding and access to science content and reasoning.

Theme 3: Careful selection of relevant technologies. Instead of adopting any and all technologies when considering integration, teachers identified themselves as picky consumers. Andrew felt that T^3-S “help[ed] me avoid using technology simply for the sake of using technology.” In order to use technology purposefully, teachers demonstrate a care and consideration for the technologies that make an impact. “The teacher needs to determine the right technology for the learning outcome and implement it strategically in order to have maximum benefit to the students (Bonnie).” Teachers will not adopt a technology unless they feel that it “suits the educational needs of the classroom (Sarah).” Taken together with the preceding themes, it is clear that teachers express a desire to integrate technologies that facilitate students’ understanding of the content, and they have no interest in technologies that do not serve that purpose.

AL Pre-questionnaire

Theme 1: Unfamiliarity with AL. One purpose of the AL Pre-questionnaire was to assess teachers’ prior knowledge, if any, of AL. Since this Pre-questionnaire was administered prior to the AL module, most teachers expressed their unfamiliarity with adventure learning and its relationship to TPACK. Bonnie stated: “I don’t know that I fully grasp the idea of adventure learning,” and this sentiment was shared by nearly every teacher. Some teachers made general guesses, anticipating that adventure learning might "open my eyes to the various ways that I can expose my students to science (Andrew)" or "provides students with real life experiences that they otherwise wouldn't be able to have in the classroom (Kristine)." Inferring from prior experiences in T^3-S, Kevin stated that "participating in original, creative learning experiences combined with collaborative, technological activities in this course has helped me begin to understand technological pedagogical content knowledge (TPACK)," and adventure learning may do more of the same. What is clear from the responses is that teachers have very little knowledge (if any) about adventure learning, but some are optimistic about its ability to engage students in science.

Theme 2: Supporting student engagement. In their speculation about how AL might impact their TPACK, many teachers describe their hopefulness for student engagement. Lisa was, "hopeful that this 'adventure learning experience' will help me think up more creative ways to create lesson plans that engage my students." Teachers like Andrew, "hope[d] to see new ways to enable [his] students to apply their scientific knowledge to the world." Marc expressed some skepticism regarding the ability for AL to promote student engagement, stating, "I feel like it may lead to disengagement if it is conducted over a long period of time and students are not be [*sic*] interested in the particular issue." Teachers hope that AL catalyzes engagement for learning science, something that they value for their future instruction. However, they do not identify elements of TPACK most likely to effect this engagement.

Theme 3: Potential for transfer to the classroom. Teachers described how their then upcoming AL experience had the potential to impact how they integrate technology into their classroom. Marc thought that, "If the [AL] activity done in our class shows promise, then I may use something like this." Other teachers spoke about technology and TPACK more generally: "I think it will cause me to be thinking about how I can incorporate technology into my classroom without awkward interruption into our routine (Bonnie)." For some, like Geoffrey, this belief was rooted in past experiences in T^3-S: "So far it [the course] has made me reevaluate my ideas of how to use technology into my classroom." In short, teachers anticipated the potential for the AL experience to cause them to think differently about how they integrate technology and TPACK into their classroom instruction. This is likely influenced by teachers' previous engagement in T^3-S activities that leverage technology-driven strategies.

AL Post-questionnaire

Theme 1: Balance within TPACK, revisited. After participating in the AL experience, teachers developed a greater understanding of not only AL but TPACK as well. In particular, teachers re-imagined that "happy medium" of technology, pedagogy, and content after participating in AL. Lisa described how, "this experience required the use of pedagogical and technological knowledge more than content knowledge...This experience opened my eyes to really exciting ways to use technology in the classroom." Other teachers described a stronger connection between technology and content: "I feel that adventure learning expands the use of technology and goes much deeper into content knowledge as well as globally relatable ideas. I think this only strengthens and complicates the TPACK model (Kristine).” Similarly, Bonnie understood through this experience how:

> Technology made it possible for students to experience something they normally would not be able to. Students are able to engage in the content without being distracted by the technology portion. It was just a really great example of that seamless tech integration that TPACK requires...Overall, this experience showed me how well technology could support both content and pedagogy seamlessly within a science classroom.

For these teachers, AL facilitated a shift in how they understood the complex balance of priorities within TPACK. However, each teacher came away with a renewed interest and belief in the utility of the TPACK model regardless of their views on how the elements of TPACK are related.

Theme 2: Student engagement through collaboration and communication. While teachers were hopeful that AL would be engaging for their future students, they found that the collaborative and communicative elements of AL were what drove engagement for themselves as participants. Andrew shared how, “This experience showed me that one good use of technology in the classroom is to connect learners with other learners and enable them to collaborate.” Teachers imagined what impact this might have on students participating in a similar experience: “I had never really thought about all of the connections I could have my students make to researchers in the field or potentially other classrooms around the world (Lisa).” The opportunity to connect to other learners and content experts around the world would not only be engaging for students, but engaging in a way that supported the development of their content knowledge. Kristine imagined that:

> Students will be able to gain more experience seeing different points of view from around the world and therefore developing more content knowledge. In this particular adventure learning curriculum students will be able to study the history, science and stories behind the northern lights. These experiences would otherwise not be accessible to a lot of students.

By participating in the creation of an AL environment, T^3-S teachers learned the specific mechanisms that promoted student engagement. By creating the tools and activities for students to communicate and collaborate with other students, teachers, and researchers, T^3-S teachers found effective pathways for promoting student interest and engagement.

Theme 3: New relevant contexts for science through cultural connections. Teachers reflected on the opportunities in the AL environment for participants to make cultural connections via contexts that are new and relevant for their future students. Prior to the AL experience, only Kristine had some idea of what AL might involve, and she had directly mentioned its potential to help bring cultural relevance to her classroom, a weakness she felt she struggled with:

> As technology gets better, students will be able to gain more experience seeing different points of view from around the world...I hope to implement adventure learning in my classroom so that my students can find the content more culturally relevant but they can also see the similarities that exist between different communities when it comes to science education...What I like about these

> adventure learning activities is that they allow me to have more cultural relevance in my classroom – something that I struggle with now.

The idea that relevant contexts were important was further expanded *after* the AL experience. This idea was shared by half of the teachers, and perhaps was the ultimate take-away from this experience in that technology could afford their future students the ability to engage in culturally relevant activities. Lisa said, "Having my students recognize the various points of view of other students around the world increases relevancy and cultural competency in my lessons." This ability to connect students to others around the world "provides students with real life experiences that they otherwise wouldn't be able to have in the classroom...I like the idea of having my students communicate with students from other parts of the country or world making the content more relatable (Kristine)." For other teachers, these new contexts brought authenticity to the project. Sarah said, "It reinforced my belief in the importance of authentic learning experiences. I think it did an amazing job of demonstrating to me what 'relevance' means." Andrew observed, "It also showed me that technology opens the door to new contexts for learning science." Access to these relevant, authentic contexts is not only important in its own right, but it can provide an important perspective on the role of scientific knowledge within cultural contexts. "As I teach science, it will still be important to acknowledge cultural beliefs and perspectives and to use them to compare and contrast those ideas to scientific ideas as a way to help teach nature of science concepts and what makes certain knowledge scientific (Kevin)." For these teachers, the connections to other cultures afforded by the AL environment allowed participants to experience science learning in new, relevant, and authentic contexts.

Theme 4: Desire to transfer to the classroom. While teachers had expressed guarded interest in integrating technologies in their classroom prior to the AL experience, their interest increased dramatically following the AL experience.

> While at first I thought it would be a weird experience for me to participate in this adventure learning. However, it turned out to be a great experience to participate in I learned a lot about the Aurora Borealis and also saw how incorporating this into my classroom would be a very rewarding experience...I believe it would be a fun project to engage my students in every year. (Geoffrey)

Specific interest in bringing AL to the classroom was shared. Kristine says, "I hope to implement adventure learning in my classroom so that my students can find the content more culturally relevant." While other teachers did not call out AL specifically, they expressed their interest in incorporating some of the tools and techniques from the AL experience in their future teaching. "I am now considering the potential integration of collaboration through technology in my classroom (Lisa)." After going hands-on with the tools and strategies featured in the AL experience, teachers were very positive about bringing those same features to their classrooms.

Conclusions

Evolving Understanding of TPACK

In the TPACK Questionnaire, teachers provided a detailed description of their understanding of the role of TPACK and its application to their current and future science instruction. This is important to define before considering how participation in the AL module impacts their understanding of TPACK. For T^3-S teachers, the primary purpose of technology is to facilitate a complex and balanced teaching strategy that provides students access to more abstract science concepts. This is in line with Hughes' (2004) vision of technology integration, where teachers select technologies for their unique abilities to enhance student learning. T^3-S teachers are specific about their desire for technology to open up abstract and difficult science concepts in ways that are not possible without technology. The emergent themes not only explicitly call for a balance of technology, content, and pedagogy, but themes about technology as content support and the careful selection of relevant technologies support a view of technology implementation that goes beyond mere TK. The practice that they are describing exists in the middle of the TPACK model, where technology integration strategies are both appropriate and context-specific (Mishra and Koehler, 2006). In short, teachers understand what TPACK is, and (more importantly) what it could look like in the classroom.

Change from Pre to Post

In looking at the AL Pre- and Post-Questionnaire, the first thing we notice, perhaps unsurprisingly, is an increase in understanding about AL. While most teachers began with little to no knowledge about what AL is, responses on the Post-Questionnaire show that teachers identify AL as a manifestation of TPACK. Through creating an AL environment (complete with curriculum, context, and communication tools), teachers learned how AL requires the interplay of content, pedagogy, and technology that defines TPACK. Further, we see a refinement of teacher understanding when we compare themes from these two data sources. For example, teachers move from anticipating an increase in student engagement through the use of technology toward naming affordances for collaboration and communication as the means by which student engagement is catalyzed. Perhaps most importantly, teachers move from potential interest in implementing aspects of adventure learning in their classrooms to strongly interested. After participating in the AL experience, teachers can identify the specific tools and techniques that effect the change they wish to see from technology integration. In the context of a teacher licensure program, the importance of this cannot be overstated, as a lack of specific technology knowledge and skills is a common barrier to teachers using technology (Hew & Brush, 2007). By providing teachers opportunities to witness and practice those specific skills, they will be better prepared to enact those strategies in their classrooms.

An intriguing result is teacher interest in cultural relevance and global contexts for science as a result of the AL experience. Prior to the AL experience, only one teacher identified engaging students in culturally relevant instruction as a priority. However, half of the teachers explicitly called out culturally relevant contexts for science as important to their vision of TPACK. The power of AL environments to connect students with remote cultures and locations through authentic learning experiences is an explicit aim of AL (Doering, 2007), and T^3-S teachers participated in the construction of an environment that would make those connections possible. As a result, teachers viewed technology integration as essential to connecting their science content with global contexts and perspectives.

An unexpected conclusion is the seeming unimportance of which group teachers participated in for the AL module. One might expect that pre-service teachers in Sirius (curriculum development) might focus on technology connections to content in Chasing Aurora, or that teachers in Antares (cultural contexts) would be more apt to describe the role of AL in providing new global contexts for learning. However, we found no significant relationship between teacher responses to the questionnaires and the group that they worked with. While this finding somewhat disrupts the multiple-case design that we began the study with, it is in fact a very positive finding for technology integrationists and instructors: participants develop a holistic understanding of TPACK irrespective of their particular treatment. In other words, a teacher need not be in the group focused on communication tools in order to increase their understanding of the role of student communication and collaboration in a technology-integrated lesson. This demonstrates that exposure to even one facet of a TPACK-rich activity may allow teachers to explore the many and varied connections between content, pedagogy, and technology within the lesson.

Implications

The pre-service teachers of T^3-S expressed their desire to engage in “innovative and creative uses of technology that enable students to learn subject matter more deeply and with more curiosity than without the technology (Hughes, 2004, p. 346). Teacher participation in the creation of an online adventure learning environment provided them the opportunity to become co-creators of a learning environment that leveraged their content, pedagogical, and technological knowledge. By participating in this experience, teacher understanding of TPACK moved beyond identification of desired features of instruction and advanced towards an understanding of specific mechanisms that could amplify or transform classroom instruction. These findings underscore the importance of T^3-S within the University of Minnesota science teacher licensure program and the value of engaging pre-service science teachers as collaborators and co-creators of technology-integrated learning environments. TPACK-rich activities like the AL experience can provide science teachers with specific, applicable knowledge regarding technology integration that can make true STEM integration a reality.

CHAPTER 5

CONCLUSIONS & IMPLICATIONS

Introduction

This chapter provides an overview of the research arc behind the three studies presented in the previous chapters. The two guiding research questions that set the stage for these studies are:

3. How do beginning STEM teachers reflect on science teaching practices?
4. How do they utilize technologies to support their colleagues and themselves?

The pursuit of these questions led to three studies that address the following areas:

4. How technology helps teachers reflect on video of past teaching practice
5. How technology helps teachers solve problems in their classrooms
6. How technology helps teachers plan for integrated instruction

In this chapter, the three studies are summarized and the findings of the three studies are synthesized and discussed, with consideration for the limitations of the work. The chapter concludes with implications for future research directions and proposed design principles.

Summary of the Research Studies

The three studies focused on the impact of technological interventions for in-service and pre-service STEM teachers. The context for the first two studies was TIN, an online induction program for beginning secondary science teachers. These two studies considered the impact of technological supports on the reflective practice of participating teachers. The design interventions included VideoANT, an online video annotation tool, and Teachers as Leaders roles, a structured response protocol for an online forum activity called Venture/Vexation. The context for the third study was T^3-S, a university licensure course for pre-service science teachers designed to explore technology integration in secondary science classrooms. This study investigated the impact of pre-service teacher participation in the creation of an Adventure Learning (AL) environment on their understanding of TPACK and its role in their future science instruction. The supporting interventions took the form of three separate groups of pre-service teachers, each tasked with a specific role in the creation of the AL environment.

Summary of the Research Findings

RQ1: How do beginning teachers respond to a peer's initial annotations on their own teaching using a video annotation tool?

An analysis of teacher responses to the teaching practice of their peers within VideoANT generated five categories of response: praise/agreement, providing a suggestion, posing a question, relating to one's own experience, and summarization. Frequency analysis revealed that the most commonly occurring code, praise/agreement, represented a majority of annotations with 41% of the total number of annotations. While previous studies have demonstrated the ability of classroom video to promote the development and improvement of teachers' reflective practice (Harford & MacRuairc, 2008), beginning teachers in TIN received praise and agreement regarding their practice and were not challenged by their peers to modify or improve their practice. This is problematic, as the challenging and improvement of teacher practice is an important goal for induction programs (Luft, Roehrig, & Patterson, 2003). It is also a feature that defines successful communities of practice, where the participants are invested in collective learning and improvement (Wenger, 1998). Roehrig, Donna, Billington, and Holescher (in press) intended for VideoANT to be used as a vehicle for teacher growth and reflection of their teaching practice. However, without specific, structured supports and modeling from the instructors regarding how to interact in VideoANT, many teachers default to “nice” commentary that does not promote the reflective teacher practice that we wish to see in TIN. The findings of this study demonstrate that simply providing an affordance for reflection (in the form of digital video) does not necessarily lead to the reflection on and improvement of teacher practice that other studies have demonstrated (Luft et al., 2003; Harford & MacRuairc, 2008). Instead, specific, explicit supports for teacher discourse are required in order to foster the reflective practice that course designers and instructor-facilitators desire.

RQ2: What is the impact of Teachers as Leaders roles on group cohesion and depth of commentary in the Venture/Vexation activity?

In response to the findings of the previous study, an explicit support for discourse was implemented in a related TIN activity called Venture/Vexation. This intervention, called Teachers as Leaders roles, was added in Year 8 (2013-2014) of the TIN program. A comparison between Year 7 (where the Teachers as Leaders intervention was not implemented) and Year 8 (where the intervention was used) revealed a statistically significant decrease in group cohesion within the Venture/Vexation as a result of the

Teachers as Leaders intervention. However, after deductively coding each of the 615 Venture/Vexation posts from Years 7 and 8, a significant decrease was found in pre-reflective commentary as well as significant increases in pedagogical and critical commentary when the Teachers as Leaders intervention was present. While the Teacher as Leaders intervention appeared to inhibit organic, conversational interactions in the Venture/Vexation activity, it served to significantly increase higher-order reflective commentary around current teacher practice. The latter finding is in line with the goals of Dewey (1933) and Rodgers (2002) for using reflection on past experiences to inform experimentation with new solutions. This result also confirms the recommendation of McFadden et al. (2014) to include targeted supports for teachers' reflective practice, as less reflective commentary occurs in the absence of such supports. In short, this community of beginning teachers was able to ask deeper questions and make more rigorous recommendations regarding teacher practices by using the Teachers as Leaders roles.

RQ3: How do pre-service teachers' understanding of TPACK change after participating in the creation of an adventure learning environment?

Pre-service teachers in T^3-S helped create an AL environment as a course assignment. Teachers participated in one of three groups, (focusing on curriculum content, cultural contexts, or technological tools), which comprised the cases for this multiple-case study of the AL intervention. Teacher responses to pre- and post-surveys surrounding the AL experience were coded to generate themes for each survey. Comparison of these themes revealed that teachers in all groups developed a more specific and more nuanced understanding of the role of TPACK in science instruction regardless of which group they participated in. While teachers identified desired outcomes prior to the AL experience, teachers were able to name specific strategies for achieving those outcomes after creating the AL environment. These strategies included the use of technology tools for promoting student engagement through collaboration and communication and the power of the AL environment for creating new relevant contexts for science through cultural connections. Further, teachers expressed a desire to enact TPACK-rich strategies in their future classrooms. Interventions like the AL experience can help science teachers move beyond merely discussing TPACK towards an active involvement in the implementation of technology for the creation of rich, engaging science lessons.

Conclusions: Studies 1 and 2

Reflective Practice Requires Purposeful Design

Studies 1 and 2 illustrate the level of reflective commentary that occurs with and without targeted supports for such conversations. Both VideoANT and the Venture/Vexation activity were intended to provide teachers in TIN with an affordance for reflecting on past teaching practice (in the case of VideoANT) and current teaching practice (in the case of the Venture/Vexation). The purpose of promoting reflective practice is to allow teachers to explore their successes and struggles, identify elements of their teaching that contribute to those successes and struggles, and elicit feedback from peers that may guide the teacher towards improving their practice (Killion & Todnem, 1991; Rodgers, 2002). However, it was found that providing the social, technical, and educational affordances as described by Kirschner, Strijbos, Kreijns, and Beers (2004) was not enough; without explicit direction regarding the nature of the desired commentary in VideoANT, peers responded most frequently with praise and agreement, neither of which support teachers in improving their practice. On the contrary, we found that the addition of Teachers as Leaders roles (Dempsey, 1992) in the Venture/Vexation activity does in fact result in higher-order reflective commentary. By asking teachers to respond in a specific role (such as the scholar, the reflective practitioner, etc.), pre-reflective teacher commentary was greatly reduced, and pedagogical and critical commentary was much more frequent. This confirms the suggestion from the preceding study in Chapter 2 that explicit scaffolds can promote more reflective commentary.

The results of these studies indicate that specific, explicit supports for teacher discourse in TIN activities are needed in order to foster reflective practice. This echoes the findings of McFadden, Ellis, Anwar, and Roehrig (2014), who revealed that, without specific directives regarding the nature of their commentary, the majority of self-reflective teacher video annotations were categorized as *describing* events instead of *explaining, evaluating,* or *interpreting* events. McFadden et al. (2014) suggested that further scaffolding regarding the purpose and nature of this tool would be necessary to push teachers into higher-order commentary. These studies not only underscore the need for structured supports in VideoANT peer feedback as well, but confirm the efficacy of implementing support interventions in other TIN activities as well.

Trade-off Between Organic Conversation and Deep Reflection

The use of targeted interventions for promoting reflective practice is not without its disadvantages. The Teachers as Leaders roles reduced group cohesion in the Venture/Vexation groups, diminishing the organic and conversational nature that existed in the Venture/Vexation activities the year before. Fewer overall posts were documented, and conversation between group participants decreased. While the use of similar interventions in VideoANT was also suggested, it is possible that the number of interactions in VideoANT could similarly decrease should such interventions be implemented.

While high group cohesion is desirable, it is not necessary in order to have a healthy community of practice. Wenger (1998) notes that the group must define their own identity regarding their exploration of practice, and it seems that teachers chose to generate a small number of more thoughtful reflections in the presence of Teachers as Leaders roles. Given the choice between many interactions at a low level of reflection and a few highly reflective reflections, the designers of TIN identify the latter as being more constructive for the development of reflective practitioners. It is also important to note that another medium within TIN may be more appropriate for teacher-participants to engage in more conversational, community-building discussions. To use the Venture/Vexation activity as an example, a simple online forum only affords so much in the ways of social interactions, and we would not choose to remove an intervention that so positively promotes reflective commentary for the sake of "socializing" a forum environment. Vonderwall (2003) points out that students in online question-based discussion forums like the Venture/Vexation activity see these networks not as places for social interactions, but for the sharing of ideas. This is also true in the case of VideoANT; participants are not engaging in a casual conversation through video annotations, but instead provide specific feedback and support regarding elements of teaching practice. In short, teachers can and should seek out avenues for less reflective, community-building conversation outside of VideoANT and the Venture/Vexation activity.

Conclusions: Study 3

Hands-on Experiences Develop Teachers' Content-based Technology Pedagogy

Although the NETS, educational researchers, and state standards have defined the need for technology education within science classrooms as early as the turn of the millennium, K-12 teachers still struggle to effectively bring technology to their classrooms (Hew & Brush, 2007). More recent research has called for a change in perspective regarding technology integration, focusing less on the material aspects and more on teacher ability to leverage technology for enhancing student learning (Hughes, 2004). In order to support pre-service science teachers in becoming "technology integrationists" (Hughes, 2004), T^3-S engaged teacher participants in the creation of an online AL environment, wherein teachers went hands-on in creating a learning environment that was driven by the content-based technology pedagogy defined by Hughes (2005). Participating pre-service teachers moved from hypothesizing about TPACK-rich instruction to defining specific mechanisms for future technology-integrated instruction as a result of this experience. The intervention of taking teachers "hands-on" with the creation of a learning environment that leverages technology, content, and pedagogy in a coherent way developed their understanding of the nature of TPACK and allowed them to define their content-based technology pedagogy for future science instruction.

This raises an interesting point relating to studies 1 and 2 regarding the role of affordances in technologically-enhanced learning environments (Wang & Hannafin, 2005) such as TIN and T^3-S. In VideoANT and the Venture/Vexation activity, teachers struggled to promote reflective commentary between one another without explicit supports for interaction; merely providing the technological affordance does not result in its use for critical reflection. However, pre-service teachers who leveraged content, pedagogy, and technology in the creation of the Chasing Aurora AL environment focused on the role of technology tools to create spaces for communication and collaboration for students to interact with one another and with people around the world. For the teachers enrolled in T^3-S, one of the most powerful uses for educational technology is to promote interaction among participants. This is a defining feature of AL (Doering, 2006) and the essential ingredient for success in an online induction program (Kennedy & Duffy, 2004). However, there has been no research on induction programs wherein participating teachers create the environment that they learn in. Should the pre-service teachers go on to enroll in TIN as in-service teachers, it would be worthwhile to explore if and how their experiences in creating a technologically-enhanced learning environment impact their use of technological affordances in TIN.

Limitations

While these studies broaden our understanding of how technology drives the practice of new STEM teachers, there are limitations that must be taken into consideration. The most important limitation is the fact that the author was the instructor-facilitator in both TIN and T^3-S. As the data collected for each of these three studies were in the form of graded course assignments, there is a potential for response bias due to power dynamics between the teacher-participants and the instructor-facilitator. Additionally, since the instructor-facilitator was also the researcher, there is potential bias towards reporting findings that favor the intervention created by the instructor-facilitator. This effect has been mitigated by the inclusion of collaborators and co-authors in the research study, as well as the fact that the instructor-facilitator is motivated to genuinely improve teacher outcomes and assess interventions accordingly.

Future Directions and Design Principles

TIN and T^3-S are complex technologically-enhanced learning environments, and the studies presented here provide glimpses into the many experiences that together promote deeper reflection and improve practice for the teacher-participants.

Relationships Between Teacher Posts and Peer Responses in VideoANT Annotations

McFadden et al. (2014) explored how teachers used VideoANT to reflect on video of their own teaching. Study 1 considered the ways in which these teachers' peers provide feedback to their peers through VideoANT. While it has been beneficial to investigate these two kinds of video annotation separately, future work might consider possible relationships between the nature of the initial posts from the teacher and the responses that the peer provides. For example, do more reflective initial posts influence the nature of the peer responses? Does the subject of the initial post have an effect on the reflective nature of the response? Work that explores questions such as these could shed light on the factors that influence teachers to respond more critically and provide more support to the teachers that are eliciting commentary on their teaching practice.

The Relationship Between Topic and Reflection in Venture/Vexation Discussions

While the effect of the Teachers as Leaders intervention on reflective commentary in TIN was significant, it cannot be assumed to be the only factor impacting teacher reflection in the Venture/Vexation activity. One avenue for future work in this area would be to explore the relationship between the initial Venture/Vexation topic and the level of reflective commentary for the responses that followed. Does a presenter topic that is coded as critical result in more critical responses from other group members? Or, more generally, does the subject of the initial post (classroom management, differentiation in the classroom, etc.) have an effect on the reflective level of posts that follow? An understanding of these relationships, if they are indeed significant, would provide a more robust understanding of what factors drive teacher reflection in the Venture/Vexation activity.

Relating TPACK Principles to Practice

In T^3-S, we observed the effect of involving pre-service teachers in the creation of an AL environment on their understanding of TPACK principles. While this provided evidence of their vision for future science instruction, a future study could follow up with these participants and observe how their science instruction did or did not align with their understanding of TPACK principles. It would be valuable to know the relationship, if any, between the views expressed by the pre-service teachers and the practices they engage in, either in their initial licensure practicum experiences or in their first years of licensed teaching. In a review of the literature, Mansour (2009) notes that the primary factors that prevent science teacher beliefs from being enacted in the classroom are external constraints such as time, resources, and learner behaviors. As the teachers in T^3-S had just begun teaching in classrooms for the first time during their field teaching experience, they had limited opportunity to experience these constraints and grapple with them as new teachers. A follow-up investigation during their first full year of classroom teaching would help to define the connection between teachers' vision for future action and the action that they actually engage in when in the classroom.

DBR and the Shifting Landscape

In addition to suggesting new directions for future research, a revisiting of our paradigmatic approach to DBR is warranted. The iterative nature of DBR requires that initial guiding principles are reassessed in light of both findings and conclusions, and our work would be incomplete without reevaluating the structures and choices that guided this work. At the outset, our paradigmatic approach to DBR stemmed from a desire to seek what McKenney and Reeves (2013) described as "the most powerful overlap" of research interests and practitioner needs (p. 89). The results of each study not only modify our research interests by answering questions and posing new ones, but the conclusions regarding each intervention also define and redefine the needs of the teacher-practitioners in these studies. Therefore, we have refocused our research efforts from study to study in light of these findings and conclusions, reassessing the landscape of research knowledge and recommendations for practice.

This “shifting landscape” approach has been moderately successful. After identifying the need for explicit reflective practice supports in the VideoANT activity, the recommendations therein led to the creation and assessment of a support intervention in the Venture/Vexation activity, which was found to be beneficial to the reflective practice of those teachers. This is an example of research findings from one study driving the implementation and evaluation of a support that directly helped teachers in the same environment. However, one way in which this approach can be made more rigorous would be to iterate changes within the same activity, not just the same learning environment. For example, a follow-up study to the work presented in Chapter 2 could present a comparison between past VideoANT interactions (where an intervention was not present) and recent VideoANT interactions from teachers who experience the intervention of structured guidelines for video annotations. This second study could validate the conclusions of the first and present a model for future instruction, which could be further refined if needed based on the conclusions therein. While this approach is time-consuming and does not explicitly apply conclusions to other activities (such as the Venture/Vexation), it is a more traditional and more robust exploration of implementation and teacher outcomes within a single activity.

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APPENDIX A
FOUR PRIMARY COMPONENTS OF TIN

This appendix is adapted from Roehrig, Donna, Billington, and Hoelscher (in press). It describes the four primary components of the Teacher Induction Network, or TIN.

Reflective Journal

The journal is the only TIN component not shared with the other beginning teachers. The journal is a place for beginning teachers to "process" their professional experiences. The journal provides a window into the emotional well-being of each beginning teacher and the ability to provide “just in time” mentoring and advice. For instance, these journals have permitted TIN facilitators to support teachers as they negotiate complicated professional interactions such as co-teaching. TIN participants have also used this as a space to communicate personal problems such as work-life balance. These more private communications permit the TIN facilitator to ensure that the novices receive the support they need to be successful either from the facilitator directly or by suggesting external resources.

Most frequently, though, TIN participants utilize their journals to describe their day-to-day experiences with students which do not “fit” into the other components of TIN. For example, a journal entry from a beginning teacher in September of their first year stated,

> It’s hard to believe that I have been teaching for almost a month! I have learned SO much during the last several weeks and I know I have more to learn…[One]

> teacher is very nice and always comes by my room to check on me throughout the day. The support I have from the faculty and staff is more than I could have ever asked for.
>
> I have one “problem” hour (4th hour)…. In this class, I have 30 students…Three speak little to no English and work with an ESL para-professional. Three are at a very low reading level and work with a Special Education para-professional. At least nine students are currently taking an ESL class, but are able to read, write, and speak English and don’t need to work directly with a para during class….

From the sample journal entry, the TIN facilitator knows that that this teacher has good support in her school setting, as well as critical information about an area of concern – her ESL students – which allows the facilitator to provide specific and focused support. Common concerns identified in the reflective journals of multiple participants are often developed by the facilitator into a topical response for SLC discussion in the topical responses component of TIN (described below). For example, analysis of journal entries over the past seven years, has shown that every year beginning teachers hit an emotional wall in February, this knowledge allows the facilitator to be pro-active in supporting beginning teachers during difficult times.

Topical Responses

The topical response is a threaded discussion around a prompt provided by the facilitator. These topics are selected based on known needs from the literature related to supporting novice teachers such as developing an inquiry oriented classroom culture, accessing professional development opportunities, and communicating with families. Additionally, emergent topics develop from common concerns bubbling up from the reflective journals or educational issue in the news. For example, one topical response thread was generated on the use of technology in the classroom. This topic was chosen in response to some questions raised in the reflective journals about technology and was used to help move teachers from viewing technology as a classroom management issue to a possible instructional strategy. Teachers actively debated the use of cellphones as instructional tools in the classroom while acknowledging school rules against cellphone use. One teacher commented,

> I believe technology in the form of personal electronic devices can be used to great effect in organizing information and record keeping, in offering *fast* feedback, and for facilitating greater moment-to-moment participation. The key is reducing the potential for distraction when using the tool.

All of the teachers spoke to issues with technology integration in their classrooms – not having access to laptops or clickers, lack of technical support, and even lack of access to low technology devices such as calculators and stopwatches. This teacher commented directly on the issue of cost and the ready access and utility of cellphones,

> The fact that the students already have cell phones makes the cost of the technology almost nothing. Buying clickers, iPods, and cameras for an entire class can be very spendy. Students really like using their own technology, and showing them how to use it in school can help them get ideas for how to better explore

> their environment outside of school. The most challenging thing, however, about using cell phones in the classroom is the ease of misusing them.

Another teacher responded,

> I do have students USE their phones in class frequently. I have had them double check conversions using applications on their phones, as well as use them for calculators and stopwatches. When we get to Electricity and Magnetism, we'll use them to demonstrate the concepts of a Faraday cage.

Teachers shared specific ways to use cellphones as clickers and collect feedback on students learning. They also shared strategies they had used in laboratory settings using pictures and video both to augment laboratory reports and class presentations and to provide information on laboratories and demonstrations for students absent from class. A teacher commented back to one of her peer's about using images in biology laboratories,

> I like your idea of using camera's to take photos of dissection and then using the photo's to study. Even posting some of the photo's to a class website so all the students could have access to particularly good dissection photos.

The role of the facilitator in this setting is initially to determine an open-ended topic for discussion that both addresses beginning teachers' concerns and pushes their thinking. Unless a discussion takes an inappropriate turn, the facilitator wraps up the conversation at the end of the discussion period; in this case applauding the teachers' innovative and student-centered uses of technology while cautioning them to consult administration about extensive cellphone use and application of social networking sites, such as Facebook.

Venture-Vexation

This component is implemented through Small Learning Communities organized by subject matter and grade level. Each month one beginning teacher in the SLC posts a venture or vexation for group discussion. A Venture is an opportunity to adventure into new curriculum, technologies, and teaching strategies. A Vexation is an opportunity to reflect on a difficult situation and get some feedback. Primarily teachers posted vexations that the small groups worked on together using readings suggested by each other and the instructor creating a plan for resolution. The following abbreviated example is from a vexation posted by a beginning secondary mathematics teacher,

> My situation deals with the challenge of balancing teaching my curriculum with (for lack of a better term) teaching to the test. At the alternative school that I work at our students are required to take a standardized test three times a year. This test measures the student's current [math] levels, and we use this test to track the growth of our students. The district uses it to keep tabs on how are the students in our school are progressing.
>
> We just completed the first of these three examinations. The scores of many of our newly enrolled students, as well as many of our veteran students, were not good….

> My goal is to find a balance between adequately preparing these students for these standardized tests, but not being forced to do it in the traditional “drill and kill” way. I hope to find more effective ways to incorporate these topics into my projects, but I feel slightly overwhelmed at the thought. [It is a] long list and there will be more pressure as the year goes on to see improvement in all areas. Do I concentrate solidly on a few, or do I skim a little from all of them and hope for the best? I guess what I am looking for from you is any ideas, suggestions, or feedback given this type of situation.

Peers offered suggestions and advice drawing on reform-based practices learned in their teacher preparation programs that they had implemented in their own classrooms. One SLC member suggested,

> I had my students work on a "capture-recapture" activity where they simulate a fish or wildlife tracking system. They use beans, or candy, or whatever you want... We were able to work with percent and rational numbers a TON through the simulations. Students had to make sense of their ratios and convert them to decimals so they could come up with "representative ratios"... It was necessary to work with fractions and decimals and percent for the activity. SO! It was very hands on/real world, while being very drill and kill-like.

Another SLC member suggested having students teach each other,

> Have you tried any variations on having the students teach each other? I know sometimes when I've been having difficulty getting students to understand a particular concept if I have them explain the material or demonstrate a method to

each other, whether in small groups or as a presentation/working a problem on the board in front of the entire class it can help students of all levels. This simultaneously forces the student presenting/teaching to process the information more fully than they normally do while exposing students who are having difficulty understanding the material to alternate explanations that might make more sense to them.

From the group discussion, the beginning mathematics teacher formulated a plan for the second quarter to create real-world projects that would incorporate a variety of activities and strategies to review and practices fundamental mathematics concepts and skills. He acknowledged that, "it may take the entire 2nd quarter to achieve these goals," to which the facilitator encouragingly responded,

> I like that you're going to use a variety of methods, I think this is vital to reaching all students and helping them develop a robust understanding of the material. I wouldn't worry about it taking an entire quarter to achieve your goals. The goals are important and by spending enough time on them, you can actually do a good job of fulfilling them.

Professional Development Inquiries (PDIs)

As part of the program requirements, the beginning teachers participate in PDIs that allow them to investigate an area of concern or an area of their teaching that they would like to improve. Prior to starting each PDI, teachers complete a self-assessment using Danielson's Framework for Teaching (2007). Danielson's framework is used in many schools and thus provides a common reference for teachers as they navigate between district language and evaluation and expectations of the TIN program. Specifically, teachers were asked to evaluate themselves and identify areas for growth related to the five components of the instructional domain: communicating clearly and accurately, using questioning and discussion techniques;engaging students in learning; providing feedback to students, and demonstrating flexibility and responsiveness The PDIs are designed to help new teachers focus upon student learning and student work, by critically examining their own teaching in relation to their beliefs and commitments, and develop the skills of data collection, analysis and reflection. Many participants select PDIs based struggles which have emerged in other components of the TIN. As described in our early versions of TIN, each PDI is approximately eight-weeks long and follows a learning cycle in which the participants plan for action, implement, and reflect on their actions with the continuous support of the TIN facilitator. During the PDI, teachers develop lesson plans and assessments to meet their PDI goal with the culminating assignment being a reflection on the video-recorded classroom implementation. Our unique online video reflection process is described in the following section.

APPENDIX B

COURSE SYLLABUS FOR T^3-S

This appendix includes the course syllabus for Technology Tools for Teachers – Science, or T^3-S. In the syllabus, the course is referred to by its university designation of EDHD 5007. Course expectations and objectives are described therein.

EDHD 5007: Technology for Teaching and Learning Science

CEHD | College of Education + Human Development

UNIVERSITY OF MINNESOTA

Course Syllabus

Instructor

Joshua A. Ellis, M.Ed. *(University of Minnesota – Science Education, 2012)*

Contact information:

E-mail: ellis228@umn.edu
Phone: 612-626-1696
Office:
320T Learning and Environmental Sciences Building
1954 Buford Avenue
St. Paul, MN 55108

Office hours:

By appointment or virtually via Skype, FaceTime, or Google Hangout.

College of Education & Human Development Mission Statement

The College of Education and Human Development is a world leader in discovering, creating, sharing, and applying principles and practices of multiculturalism and multidisciplinary scholarship to advance teaching and learning and to enhance the psychological, physical, and social development of children, youth, and adults across the lifespan in families, organizations, and communities.

Conceptual Framework for P12 Professional Education Programs

The central themes of the conceptual framework are:

- Promoting inquiry, research, and reflection;
- Honoring the diversity of our communities and learners; and
- Fostering a commitment to lifelong learning and professional development.

EDHD 5007 promotes inquiry through investigating the effective uses of technology in education; fosters reflection with every performance assessment as the students discuss their learning processes and the impact of technology integration in their future classrooms; celebrates the diversity of the class, society, and our future classrooms; and encourages lifelong learning and professional development.

Course Goals and Objectives

This course is designed to prepare you to become knowledgeable and comfortable integrating technology into the science education classroom.

> **Goal: *Learn to thoughtfully integrate technology within research-based science education instruction to enhance student learning of specific content.***

Upon completion of this course, you should be able to:

- Develop strategies to learn how to learn technology;
- Develop a personal understanding of the affordances and limitations of specific educational technologies;
- Plan classroom instruction that integrates technology;
- Choose and justify the choice of specific technologies to teach particular concepts.
- Identify barriers that you may encounter towards integration of technology and how to overcome them;
- Use educational technologies applicable to science education classroom settings;
- Develop a vision for teaching and learning science education supported by technology.

Course Meetings

There are seven class meetings. During these seven meetings we will explore many educational technologies hands-on and discuss their appropriate uses. Course pacing will be responsive to student needs.

Course Website

This course features a hybrid/blended design, incorporating both face-to-face and online elements of instruction. We will use Moodle as our course website. The website can be accessed through https://www.myu.umn.edu/ You will be automatically enrolled in this private, secure network and you will need to become familiar with its features. You will be using it to communicate with others, find assignments, submit assignments, and many other activities within the course.

Readings

All the readings for this class can be downloaded or accessed from our course management system, Moodle, and will be provided module by module.

Course Gradebook

We will be using the gradebook in Moodle. It is your responsibility to follow your progress, assignment points received, current grade in the course, etc. You should be doing this regularly throughout the course. Your course progress and ensuring you are completing all necessary coursework is your responsibility.

Technology Tools

Access to the following technologies will be required to successfully complete this course:

- Computer connected to the Internet
- Firefox web browser (IE or Safari may not work well with Moodle and other technologies)
- A University of Minnesota Google Apps account (http://www.oit.umn.edu/google/getting-started/index.htm)

Learning how to use course technology

This course will use a number of technologies to facilitate discussion and learning of the materials. One of the course goals is to become a better independent learner of technology and technological problem solver. Software changes rapidly which means learning a particular product/version is less important than learning the concepts and processes undergirding software. We focus on the skills to independently learn new software. ***This requires practice and a ton of patience*** – however it will pay off for you and your students!

The following strategies can be employed to help solve problems in the following order:

1. Play/experiment with the new technology to learn its features and affordances
2. Use an online search engine to find help for a specific problem
3. Consult the software help file
4. Seek base group member assistance
5. Seek instructor help

Group Work

Learning in this course is framed by research on communities of practice. We learn from and with one another. We enact this vision through a cooperative learning strategy called base groups. You will complete many discussions and activities with your base groups. You will be permitted to choose your base group during the first module of class.

Our online community will be highly interactive and fun, but please understand that it does require that you be a very self-motivated, independent learner in order to stay on top of assignments and coursework. **Your timely participation is extremely important to complete the**

assignments and projects AND to the learning of your base group members. You will have individual, small, and class-wide work throughout the semester.

The following are a list of base group norms that we will use throughout the class:

1. Be prepared and ready to learn so you can support the learning of your group members.
2. Be open to new ideas and ways of approaching problems from your group members.
3. Find a balance between providing direct instruction and facilitated coaching with your group members.
4. Make sure to attend to discussion due dates to improve learning for all members.

Deadlines & Late Assignments

The deadlines for all assignments will be clearly communicated in person and via our Moodle page. If you cannot complete your work by the deadline, you must make an arrangement with the instructor **before the deadline**. Any assignments submitted late (or not at all) with no prior communication will not receive credit.

Course Assignments Overview and Grade Breakdown

Flipgrid Share-outs (10%)

These will be opportunities to respond to brief prompts with a 90-second video using Flipgrid. You can view the responses of your peers and quickly hear the perspectives of your peers.

Discussions (online and face-to-face) (20%)

These discussions will happen in class and online using the forums in Moodle. Online discussions typically involve a new post from you and a reply to a peer's post.

Purpose Statements (20%)

These will be a series of structured questions that will be asked of you at specific milestones in the course. Their purpose is to chart your evolving perspectives related to technology integration in science teaching.

Tech-integrated Mini-unit Lesson (20%)

This assignment will dovetail with your middle school practicum experience, where you will be asked to integrate technology in one of your mini-unit lessons.

Technology Integration Teaching Event (30%)

This is the capstone assignment for the course, where you will create a 20-30 minute lesson to teach us that utilizes effective technology integration. This lesson will take place on the last day of class (12/5).

More details about each of these assignments can be found in class and on our Moodle page.

University Policies

Student Conduct Code:

The University seeks an environment that promotes academic achievement and integrity, that is protective of free inquiry, and that serves the educational mission of the University. Similarly, the University seeks a community that is free from violence, threats, and intimidation; that is

respectful of the rights, opportunities, and welfare of students, faculty, staff, and guests of the University; and that does not threaten the physical or mental health or safety of members of the University community.
As a student at the University you are expected adhere to Board of Regents Policy: *Student Conduct Code*. To review the Student Conduct Code, please see:http://www1.umn.edu/regents/policies/academic/Student_Conduct_Code.html.

Note that the conduct code specifically addresses disruptive classroom conduct, which means "engaging in behavior that substantially or repeatedly interrupts either the instructor's ability to teach or student learning. The classroom extends to any setting where a student is engaged in work toward academic credit or satisfaction of program-based requirements or related activities."

Use of Personal Electronic Devices in the Classroom:
Using personal electronic devices in the classroom setting can hinder instruction and learning, not only for the student using the device but also for other students in the class. To this end, the University establishes the right of each faculty member to determine if and how personal electronic devices are allowed to be used in the classroom. For complete information, please reference:http://policy.umn.edu/Policies/Education/Education/CLASSROOMPED.html.

Scholastic Dishonesty:
You are expected to do your own academic work and cite sources as necessary. Failing to do so is scholastic dishonesty. Scholastic dishonesty means plagiarizing; cheating on assignments or examinations; engaging in unauthorized collaboration on academic work; taking, acquiring, or using test materials without faculty permission; submitting false or incomplete records of academic achievement; acting alone or in cooperation with another to falsify records or to obtain dishonestly grades, honors, awards, or professional endorsement; altering, forging, or misusing a University academic record; or fabricating or falsifying data, research procedures, or data analysis.
(Student Conduct Code: http://www1.umn.edu/regents/policies/academic/Student_Conduct_Code.html)

If it is determined that a student has cheated, he or she may be given an "F" or an "N" for the course, and may face additional sanctions from the University. For additional information, please see:http://policy.umn.edu/Policies/Education/Education/INSTRUCTORRESP.html

The Office for Student Conduct and Academic Integrity has compiled a useful list of Frequently Asked Questions pertaining to scholastic dishonesty:
http://www1.umn.edu/oscai/integrity/student/index.html.

If you have additional questions, please clarify with your instructor for the course. Your instructor can respond to your specific questions regarding what would constitute scholastic dishonesty in the context of a particular class-e.g., whether collaboration on assignments is permitted, requirements and methods for citing sources, if electronic aids are permitted or prohibited during an exam.

Makeup Work for Legitimate Absences:

Students will not be penalized for absence during the semester due to unavoidable or legitimate circumstances. Such circumstances include verified illness, participation in intercollegiate athletic events, subpoenas, jury duty, military service, bereavement, and religious observances. Such circumstances do not include voting in local, state, or national elections. For complete information, please see: http://policy.umn.edu/Policies/Education/Education/MAKEUPWORK.html

Grading and Transcripts:

Final Grade will be determined using the following scales. The numbers represent percentages of possible points earned. Grades will be rounded to the nearest integer.

A 100-94 - achievement that is outstanding relative to the level necessary to meet course requirements
A- 93-90
B+ 89-87
B 86-84 achievement that significantly above the level necessary to meet course requirements
B- 83-80
C+ 79-77
C 76-74 achievement that meets course requirements in every respect
C- 73-70
D 69-61 achievement that is worthy of credit even though it fails to meet fully the course requirements
F <60 represents failure and signifies that the work was either (1) completed but at a level of achievement that is not worthy of credit, or (2) was not completed and there was no agreement between the instructor and the student that the student would be awarded an I.

For additional information, please refer to:http://policy.umn.edu/Policies/Education/Education/GRADINGTRANSCRIPTS.html.

Sexual Harassment

"Sexual harassment" means unwelcome sexual advances, requests for sexual favors, and/or other verbal or physical conduct of a sexual nature. Such conduct has the purpose or effect of unreasonably interfering with an individual's work or academic performance or creating an intimidating, hostile, or offensive working or academic environment in any University activity or program. Such behavior is not acceptable in the University setting. For additional information, please consult Board of Regents Policy:http://www1.umn.edu/regents/policies/humanresources/SexHarassment.html

Equity, Diversity, Equal Opportunity, and Affirmative Action:

The University will provide equal access to and opportunity in its programs and facilities, without regard to race, color, creed, religion, national origin, gender, age, marital status, disability, public assistance status, veteran status, sexual orientation, gender identity, or gender expression. For more information, please consult Board of Regents Policy:http://www1.umn.edu/regents/policies/administrative/Equity_Diversity_EO_AA.html.

Disability Accommodations:

The University is committed to providing quality education to all students regardless of ability. Determining appropriate disability accommodations is a collaborative process. You as a student must register with Disability Services and provide documentation of your disability. The course instructor must provide information regarding a course's content, methods, and essential components. The combination of this information will be used by Disability Services to determine appropriate accommodations for a particular student in a particular course. For more information, please reference Disability Services: http://ds.umn.edu/Students/index.html.

Mental Health Services:

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance and may reduce your ability to participate in daily activities. University of Minnesota services are available to assist you. You can learn more about the broad range of confidential mental health services available on campus via the Student Mental Health Website: http://www.mentalhealth.umn.edu.